REPORT TO CONGRESS
Public Comment and Review Draft

WATER SUPPLY-WASTEWATER TREATMENT COORDINATION STUDY

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF DRINKING WATER
WASHINGTON, D.C. 20460

Contract No. 68-01-5033

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This study and report to Congress was the overall responsibility of George W. Denning, Project Officer and Staff Economist of EPA's Office of Drinking Water. Mr. Denning coordinated both with the contractor and with the EPA Task Force, and monitored the day-to-day work effort. The Task Force, established by Thomas C. Jorling, Assistant Administrator for Water and Hazardous Wastes, was under the leadership of Chairman James H. McDermott, Senior Physical Science and Engineering Advisor in the Office of Drinking Water. Responsible for coordinating various offices within EPA Headquarters and with the Regional Offices, and for providing policy direction to the Project Officer and the contractor, Task Force members from Headquarters included: Steve Cordle, Office of Air, Land and Water Use; Richard Hager, Office of Regional and Intergovernmental Operations; Alan Magazine, Office of Planning and Management; Myron Tiemens (Alternate, Carol Wegrzynowicz), Office of Water Program Operations; Peter Wise (Alternate, Jerry Kotas), Office of Water, Planning and Standards. Regional representatives on the Task Force included: Frank Covington, Water Division Director, Region IX; Gary Hutchinson, Water Supply Chief, Region IV; Paul Walker, Engineering Branch Chief, Region VI. Several Task Force members played important roles in the organization and delivery of, as well as synthesis of, findings from the regional workshops.

Contractor on the study was INTASA, Inc. of Menlo Park, California. Subcontractors and consultants were: Hydrocomp, Inc., Metcalf & Eddy, Inc., Tetra Tech, Inc., Joe G. Moore, Jr., and Ray K. Linsley. Nicolaos V. Arvanitidis, President of INTASA and Study Manager was responsible for directing the technical team, coordinating with EPA and the Task Force, organizing the Public Workshops, and synthesizing recommendations to Congress in coordination with EPA, the technical team, and consultants and in response to Congressional request and public participation results. A Core Management Group, responsible for leading the work effort in their respective firms, providing advice to the Study Manager, and meeting

periodically with the technical team included: Frank L. Burton, Metcalf & Eddy, Marc C. Lorenzen, Tetra Tech, Joe G. Moore, Jr. and Ray K. Linsley.

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Chapter 1

EXECUTIVE SUMMARY

A. Scope

This report is submitted to Congress by the U.S. Environmental Protection Agency pursuant to the Safe Drinking Water Act (Section 1442(c)) and the Federal Water Pollution Control Act, also known as the Clean Water Act (Section 516(e)). It documents a national assessment and analysis of issues related to: (1) the adequacy and dependability of safe drinking water supplies, including quantity, quality, cost, and treatment processes; and, (2) opportunities to coordinate water supply and municipal wastewater treatment plans. The study builds on recent data and results of public workshops held throughout the country to address more specifically: (1) coordination mechanisms available through major Federal programs; (2) advantages and disadvantages of conservation and reuse; (3) contamination of groundwater resources and management improvements needed; and, (4) problems unique to small water supply systems. Options for modification of program emphasis, revision of existing legislation, or appropriation of funds are also discussed. This responds to the following statutory directives:

> "Not later than eighteen months after the date of enactment of this subsection, the Administrator shall submit a report to Congress on the present and projected future availability of an adequate and dependable supply of safe drinking water to meet present and projected future need. Such report shall include an analysis of the future demand for drinking water and other competing uses of water, the availability and use of methods to conserve water or reduce demand, the adequacy of present measures to assure adequate and dependable supplies of safe drinking water, and the problems (financial, legal, or other) which need to be resolved in order to assure the availability of such supplies for the future. Existing information and data compiled by the National Water Commission and others shall be utilized to the extent possible." (PL 93-523 Section 1442(c) as amended by PL 95-190 Section 3(3).

"The Administrator, in cooperation with the states, including water pollution control agencies, and other water pollution planning agencies, and water supply and water resources agencies of the States and the United States shall submit to Congress, within two years of the date of enactment of this section, a report with recommendations for legislation on a program to require coordination between water supply and wastewater control plans as a condition to grants for construction of treatment works under this Act. No such report shall be submitted except after opportunity for public hearings on such proposed report." (PL 92-500 Section 516(e) as amended by PL 95-217 Section 72).

The scope of these legislative directives is quite broad. In several instances there is overlap with other Congressional requests for reports or with current activities which are addressing specific problem areas. In those cases, this report and, in particular, the recommendations defer to the reports and activities that are more narrow in scope and, consequently contain more depth. Major ongoing activities which supplement this report include:

- Water Allocation/Water Quality Coordination Study -- an EPA report to Congress, in response to Section 102(d) of the Clean Water Act, addressing the relationship between programs under that Act and programs which state and Federal agencies use to allocate quantities of water. Draft copies of the report are available and the final report will be completed in September 1979.

- Water Utility Financing Study -- an EPA report to Congress in response to Section 1442(a)(3)(B) of the Safe Drinking Water Act estimating the cost of compliance with primary drinking water regulations for both large and small communities and studying potential financing mechanisms. The study is underway and should be completed by September, 1979.

- Proposed Organics Regulations -- an EPA activity now in progress to update the interim primary drinking water regulations relative to trihalomethanes and synthetic organic chemicals. It is expected that by the end of the year EPA will promulgate a THM regulation and will repropose regulations to control synthetic organic chemicals.

- Strategies for Funding of Multiple Purpose Projects -- EPA guidelines being developed on the extent of wastewater construction grant funding elibibility of projects which include other purposes such as urban drainage (in conjunction with combined sewer problems), co-incineration of wastewater sludge and solid waste, or water supply (through wastewater reuse). A report with seven options has been completed. Seminars are now being held for the public.

. Improvement of Groundwater Planning and Management -- a recently initiated EPA effort to develop a unified technical basis and policy direction for several mandates regarding groundwater quality under the Safe Drinking Act, the Clean Water Act and the Resources Conservation and Recovery Act.

. Review of Level B Study Impacts -- a review by the Water Resources Council (WRC) of past Level B plans in response to a request by the Office of Management and Budget to assess the efficiency and effectiveness of the program through case study analyses of the objectives, results and impacts of such plans. The WRC has just completed a draft report that is likely to undergo revisions.

. The President's Water Policy Initiatives -- several aspects of these initiatives, presently being considered by Congress or being further developed or implemented by the Executive Branch, are related to the present report, including:

  - Additional funds for WRC Title III planning assistance grants to states for comprehensive state water management programs.

  - New funds for grants to states to establish water conservation technical assistance programs.

  - Study of urban water supply and distribution problems being initiated by the new Intergovernmental Water Policy Task Force.

    Reports of the water conservation policy implementation task forces, particularly the report on present grant and loan programs for water supply and wastewater treatment facilities.

In addition to the above, the scope of this report was influenced by Congressional concern for drinking water supplies and municipal wastewater control plans explicit in Sections 1442(c) and 516(e) respectively. Broader water supply/water resources plans and water quality management efforts are addressed only when they are relevant to these statutory directives.

B. Recommendations

Recommendations developed during this study are believed to be responsive to Sections 1442(c) and 516(e) as well as sensitive to the prevailing public preference, as expressed in the public workshops, for full implementation of existing statutory authorities before resorting to new legislation, and widespread citizen dissatisfaction, as reported in the media, with increasing governmental regulations and new Federal programs. In addition consideration was given to the fact that existing programs have only been operational for a short time; thus results have not been fully realized and therefore cannot be evaluated. Furthermore, Congress devoted considerable time in amending the Clean Water Act and Safe Drinking Water Act in 1977, and therefore extensive reexamination is premature.

The following provides recommendations for Congressional consideration and reports actions which the Administrator intends to take. Major findings in support of these recommendations and actions are presented in subsequent sections.

1. Strengthen the Water Quality Management Program

EPA activities in response to Sections 106, 208, and 303 of the Clean Water Act have recently been consolidated into a new "Water Quality Management Program" (WQM) and regulations have been streamlined and revised. Emphasis has been shifted in the program and new regulations from plan development to implementation of plans, continued water quality planning within the states and designated areas, and formalizing each state's commitment to progress through a State-EPA Agreement which is a prerequisite to EPA's yearly obligation of planning and management funds to the states. It is recommended that:

- The Administrator should act under his present authority to slightly expand the scope of the WQM program by requiring WQM plans to contain program areas which address: (1) water conservation, recycling and reuse as they pertain to water quality; (2) integrated quality/quantity planning for surface and groundwaters and for their interactions as related to water quality; (3) public water supply and wastewater management plan coordination; and (4) water quality management and hazardous waste disposal plan coordination.

- Congress should provide increased and stabilized appropriations under Section 208 of the Act so that: (1) continued progress can be made towards managing and refining the implementation of present WQM plans; and, (2) the increased scope as noted immediately above can be accomplished.

Adoption of the above will increase opportunities for coordination in response to 516(e) prior to Step 1 planning of wastewater facilities, build upon EPA-State-local partnerships already established through initial rounds of 208 and 303 planning, improve opportunities to provide adequate quantities and qualities of drinking water in response to Section 1442(c), and identify opportunities to implement conservation or reuse and improve groundwater management.

2. <u>Designate a Lead Federal Agency for Municipal Water Conservation</u>

This study focused on municipal water conservation in response to Congressional concerns discussed above. It is recommended that:

- The President should designate a lead Federal agency for municipal water conservation. This agency should be responsible for directing research efforts and relevant data gathering, for synthesizing and presenting practical, comprehensive information on the advantages and disadvantages of municipal conservation, and for providing technical assistance to other Federal agencies, to states, and to relevant national organizations.

- Congress should provide appropriations for the designated agency to carry out this responsibility.

It is noted that a similar action may be warranted for agricultural and industrial conservation. It (and the extension to include agricultural and industrial conservation) would be an important supplement to the President's Water Policy Initiative of providing grants to states for programs of technical assistance to local entities interested in conservation. Successful implementation of a program would provide opportunities to improve the adequacy of water supplies in response to Section 1442(c), effect water quality benefits, reduce facilities and construction and operation and maintenance costs in response to 516(3), reduce national energy costs for households and communities, and reduce national energy imports and the balance of payments deficit.

3. Modification to the Construction Grants Program

The EPA construction grants program mandated by the Clean Water Act and providing funds for planning and constructing publicly owned treatment works, and related funding programs of FmHA, EDA and HUD, can easily contribute toward better coordination of water supply and wastewater treatment plans. Recommendations are:

- The Administrator should reemphasize existing facilities planning guidance (Step 1) to assure earlier and more complete identification and consideration of interactions between wastewater management alternatives and area water supplies, especially public supplies and groundwater.

- Congress should authorize provision of a construction grants bonus of up to 5 percent (i.e., 80 percent of eligible costs rather than 75 percent) to communities with demonstrated success in achieving water conservation/wastewater flow reduction; or up to a 5 percent penalty should be applied to funding of projects in communities with excessive per capita wastewater flows.

Implementation will encourage coordinated planning in response to 516(e) and promote water conservation in response to 1442(c); the cost for wastewater facilities would be equal to or less than under present requirements.

4. Synthesize and Coordinate Assistance to Small Water Supply Systems

Small Water supply systems have been singled out as having a unique set of difficulties in supplying adequate quantities of water and meeting quality regulations. It is recommended that:

- The Administrator, in cooperation with the appropriate Federal agencies and the states, should intensify actions to assist small systems (i.e., serving less than 10,000 persons) including but not limited to: (1) development and improvement of operator training material and delivery methods; (2) consolidated packaging and delivery of technical/planning/management assistance information; and (3) increased support to states for expansion of surveillance programs.

This recommendation is within EPA's statutory authority and responsibility under the Safe Drinking Water Act. Implementation will improve the capabilities of small systems to deliver an adequate and dependable supply of safe drinking water, and will increase the visibility and accessibility to Federal capital improvement assistance presently available to these systems.

5. State and Local Initiatives

Many problems will not be easily resolved by direct Federal action as they are properly part of the state and local decision making process. The following are suggested for special attention through state and local initiative:

- States should review their water laws to remove disincentives to water conservation and to require integrated surface and groundwater quantity and quality management as appropriate. Furthermore, water laws should recognize basic interactions between surface and groundwater and should address groundwater contamination problems.

- States should participate in the Administration's proposed expansion of the Water Resources Council's Title III program, the Level B program (with pending improvements), and the proposed technical assistance program on conservation.

- To protect the quality and quantity of groundwaters, states and municipalities should develop permit regulations for injection wells and waste disposal facilities, guidance for constructing, maintaining and/or terminating such facilities, and requirements for technical controls of depletion where needed. In addition, routine inspection and monitoring programs should be established.

- The states should develop or improve assistance programs to small water supply systems, coordinate such programs with complementary Federal efforts, and facilitate small system applications for available Federal financial assistance.

- States, with Title III assistance, should in concert with regional planning agencies, develop coordinated framework plans for water quality management including groundwater protection, water quantity management including conservation and hazardous waste disposal.

6. Improvements in Ongoing Activities and Programs

Several findings point toward improvements within existing EPA programs which should be possible within present authorities and budgets. These include:

- The Administrator will continue to work with the Office of Water Research and Technology of the Department of the Interior to improve (1) the state of knowledge on potential health effects of nonpotable reuse, and (2) to identify case examples on the practical potential of reuse under various generic circumstances, especially information on costs and water quality impacts.

- The Administrator should obtain guarantees that state and local agencies will maintain indirect water quality enhancement (such as lower in-stream waste loads) obtained through use of construction grants support for wastewater management projects featuring wastewater reuse and recycling of nutrients.

- The Administrator should conduct training workshops for the states on the Resources Conservation and Recovery Act and Underground Injection Control implementation.

- The Administrator should encourage state public water supply supervision agencies to work with and to make full use of information in sister agency files on the dependable quantities and qualities of each source and its vulnerability to droughts.

- The Administrator should improve technology transfer regarding technical control measures to minimize groundwater contamination from waste disposal operations and reuse technologies.

C. Study Process and Organization of This Report

The range of topics and issues associated with water supply and water quality is broad and there is a plethora of data, oftentimes conflicting or incomplete, on water use, availability, quality, funding, regulation and institutional arrangements. The need to focus on problems and opportunities of priority to the public and within EPA's purview prompted a study process which emphasized intra-agency coordination and public participation.

A Task Force, comprised of representatives from the various EPA offices responsible for programs under the Clean Water Act and the Safe Drinking Water Act, was established to select the contractor and interact with the study team throughout the study.

Public participation was initiated in the first phase of study by distributing a discussion paper and conducting two-day workshops in San Francisco, Dallas, Atlanta, New York and Chicago. Results of these workshops, the initial exploratory analysis of a broad range of issues, and direction from the Task Force were used to focus the study on topics (1) of major concern to the public, (2) within the scope of the study, (3) nonduplicative or preemptory of specific ongoing studies and reports, (4) nationwide in significance, and (5) within or closely related to EPA's major program areas.

This report is organized to reflect the study process followed: Part 1 presents an exploratory assessment of the current situation with respect to water supply and water quality as well as public concerns; Part 2 provides an analysis of priority issues; Part 3 develops explicit options and recommendations.

- Part 1 deals with the institutional/legal framework (Chapter II), availability and uses of the water resource (Chapter III), measures to protect and enhance drinking water quality and in-stream quality (Chapter IV), water quantity/quality relationships (Chapter V), cost, financing and energy considerations (Chapter VI) and public involvement in selecting priority issues (Chapter VII).

- Part 2 addresses opportunities to coordinate water supply and municipal wastewater treatment planning within EPA's Construction Grants (Section 201) and Water Quality Management (Section 208) Programs and Water Resources Council's Level B.Planning (Section 209) Program (Chapter VIII), municipal conservation and reuse (Chapter IX), groundwater management and interaction with surface water (Chapter X), and small water supply systems (Chapter XI).

- Part 3 reviews the findings of Part 2, describes the process that the study followed in screening policy options, formulates priority actions and synthesizes recommendations(Chapter XII).

D. Part 1 Assessment: Major Findings

The range of findings, resulting from the technical assessment and investigation of public views, are reported in Chapters II through VII and synthesized at the end of each chapter. The following presents the major outcome of the exploratory assessment which influenced the selection and detailed assessment of priority problems in the subsequent phase.

1. Drinking Water Availability

From a national perspective, the United States is water rich; domestic and commercial use, which includes most drinking water, is a very small portion of the total. By the year 2000, it is anticipated that national domestic and commercial withdrawals will be only about five percent of the once-in-twenty-year drought streamflow. However, local drinking water shortages have been reported on a widespread basis in the

Water Resource Council's Second National Assessment -- i.e., in over half of the 106 water resources subregions (see Figure 3.5). These shortages are not concentrated in the traditionally water-short areas of the country. They are sometimes due to inadequate water quality, failure to develop water supply facilities, and financial difficulties as opposed to more obvious causes such as local water scarcity or competition with other users. However, competition for water is intense and that intensity is increasing and spreading to many sections of the country. One result of increased demand is groundwater overdraft (pumping in excess of natural recharge; see Figure 3.6) in extensive areas of the U.S. Another is depletion of streamflows and the emerging major national concern for protecting in-stream uses. Still another is partial displacement of some present uses by other uses (such as domestic and commercial, which can usually afford to pay more for water or are sometimes given higher priority). More specific findings are:

- Localized drinking water shortages are not adequately documented in terms of severity or cause by existing Federal and state data programs.

- Water shortages are often made worse by state water allocation systems which continue to permit (and may even encourage) development of additional surface and groundwater supplies even after the sustainable yield of the resource has been far exceeded; in some states, management of groundwater withdrawals is totally neglected.

- Small drinking water systems (i.e., those serving less than 10,000 people) are believed to have more problems with shortages than large systems because they are more vulnerable to local scarcities, experience more volatile changes in demand, and are less able to provide financing to develop distant sources or overcome quality problems.

2. Water Quality

The past ten to fifteen years have seen surface water quality emerge as an issue of national importance. The first and most obvious commitment was the abatement of point source discharges. Although significant progress has been made, much remains to be done and success is very dependent on continued Federal funding.

The most important step with regard to drinking water quality was passage of the Safe Drinking Water Act in 1974 which extended Federal authority to all public systems through regulations to be implemented at the local level consistent with directions issued by state supervisory programs. Significant progress has been made through the State-EPA approach to initiating compliance with the Act but much work still remains. For example, the process of establishing primary regulations for implementation through state programs is slow and difficult and requires lengthy deliberations as exemplified by the presently proposed organics regulations.

Until recent years groundwater quality has received considerably less Federal attention, even though it is the source of drinking water for approximately 47 percent of the nation's total population and, when contaminated, cleanup is either extremely expensive or impossible because of slow groundwater movement and interaction of pollutants with aquifer materials. Recent legislation has addressed some aspects of groundwater quality, notably Underground Injection Controls under the Safe Drinking Water Act and controls over solid and hazardous waste impacts on groundwater under the Resources Conservation and Recovery Act. These groundwater provisions are in the early stages of implementation. More specific findings are:

- A strong public view was registered by the public at five regional workshops in favor of the implementation of existing statutory authority as opposed to the passage of additional legislative authority. The possible exception to this view is the adequacy of laws to prevent groundwater degradation.

- Small water supply systems have significantly more problems in complying with the interim primary drinking water regulations than larger systems do. For example, according to a preliminary assessment of 1978 data, nearly one-fourth of the small community (year-round) systems failed to comply with the regulation in contrast to one-tenth of the large community systems. Small non-community (seasonal) systems, such as those in recreation areas, are believed to have even greater difficulties.

- The costs of implementing the present interim primary drinking water regulations, which will be finalized as part of EPA's Water Utility Financing Study (see page 2), is only about two to three percent of the money needed to meet Clean Water Act commitments for in-stream water pollution control.

3. Conservation and Reuse

Both conservation (moderation of water demand) and reuse of effluents have received attention recently as a result of the Clean Water Act amendments, the President's Water Policy, and major droughts. Both have an intuitive appeal which arouses people's interest. However, beyond this first reaction, the situation is more complex.

Consider, for example, the definition of the term conservation. It is commonly used to refer to supply rather than demand management. This emphasis encourages structural solutions such as dams and reservoirs to manage water. Current administrative and legislative initiatives focus more on demand. If a primary concern is to save water so that more is available for other uses, priority consideration should be applied to agricultural irrigation. On the other hand, from a demand management perspective, water conservation can save much energy and money in addition to saving water; in the case of municipal and industrial water use, such savings include major surface or groundwater supply, water treatment, distribution and pumping, and wastewater treatment operations. The situation is, however, complited because the advantages of conservation vary from location to location. In coastal locations where fresh water is withdrawn, used once and discharged to the ocean, a savings in withdrawal can make water available for another use or uses. Similarly, reuse of wastewater can substitute for fresh water supplies. Inland, savings in consumption (i.e., consumptive loss due to evaporation) are more important than reduced withdrawals since it is only consumed water that is not available for another use. An overall effective conservation effort may also create problems in times of drought since additional drought-induced reductions could then be difficult to achieve without hardship. Over the long term, municipal conservation could reduce or delay the need to expand water supply or wastewater treatment facilities. For the short term, however, and in the absence of a phased program, if a utility's water sales decrease, it might have to raise rates to meet its financial obligations.

The complexities of reuse also need to be recognized. Reuse is already widespread on an indirect basis wherein wastewater discharged to a natural water course by one user is withdrawn downstream by another. Such indirect reuse can account for as much as one gallon out of five of a municipality's water supply at downstream water intakes. Similarly, downstream agricultural users are also often involved and wastewater may be put through several cycles of indirect reuse.

Direct reuse, which involves a pipeline or similar conduit from one user to the next, also occurs widely. Approximately 536 projects utilize about 760 million gallons of wastewater per day, mostly for agricultural and landscape irrigation, and industrial cooling purposes. Clearly, direct reuse is feasible in some locations but requires site specific analyses of technical, economical and institutional alternatives. Since it depends greatly on local circumstances, the overall desirability for expansion is difficult to extimate. In addition, direct reuse may encounter water rights restrictions since downstream flows may be reduced, and possibly inadequately understood health risks create barriers. Specific findings are:

- People in a position to implement conservation or reuse have difficulty making a judgment on its potential for their situation.

- This is largely due to the inadequacy of presently available information regarding the balance between advantages and disadvantages of conservation and/or reuse which are likely to be encountered in typical situations.

4. <u>Interrelationships and Institutions</u>

The importance of recognizing interrelationships among various aspects of the resource has increased dramatically. As a result of intense surface water resource development and programs impacting water quality, coordinated management approaches are generally hampered by the many agencies, at all levels of government, having different mandates and objectives for managing the same resource. Most states, for example, have one agency responsible for water supply and another for water pollution control. This split often hampers coordination. Because surface water development has already been intense, additional sites (which are economical, physically feasible, and environmentally acceptable) for new development are harder to find; thus additional supply has been sought from groundwater without due recognition that surface and groundwater are parts of one and the same resource. Observed effects of this uncoordinated institutional approach to withdrawal and use of groundwater include unavailability of water to seep into streams during low flow periods, decreases in surface water availability, and saline contamination of aquifers when water withdrawal exceeds safe yield.

Similar examples of an uncoordinated approach to water quality management can be cited. Emphasis has been on controlling waste discharges as the obvious "cause" of poor water quality during summer low flow and although impressive results have been achieved in abating the most blatant municipal and industrial pollutant loadings, poor water quality during low flow periods is still a problem. Thus attention is now shifting to the low flow itself, often the result of many upstream diversions, as a contributing cause. However within the existing institutional framework such diversions may be growing with the prospect of progressively lower streamflows and nonattainment of water quality standards. Major findings relative to the existing institutional framework include:

- The quantity and quality relationships of surface and groundwaters and the interactions between them are not adequately accounted for in present water resource and water quality plans.
- Water supply and wastewater treatment projects are separately planned, financed, and constructed at all levels, usually by different agencies, which often overlook key interrelationships that may result in mutual benefits.

E. Part 2 Priority Analysis: Major Findings

Findings from the initial assessment and investigation of public views as well as the statutory directives were used to identify priority problems and opportunities for more detailed analysis in the second phase of study: (1) improved coordination, (2) conservation and reuse, (3) groundwater management and interaction with surface waters, and (4) small water supply systems. Major findings are summarized below and further detail is provided in Chapters VIII through XI.

1. Coordination Through the Construction Grants Program

EPA's program for assisting municipalities through wastewater construction grants is a three-step process: planning, detailed design, and construction. Steps 2 and 3 are implementation phases; any attempt to strongly influence the project by coordinating with other functional planning efforts or dealing with problems other than wastewater treatment must occur earlier in the process. During the Step 1 "facilities planning", a local wastewater agency with a special water pollution control need is provided a Federal grant to identify the best approach for responding to that need. Since the project is so specific to the local agency and the particular need, emphasis is usually placed on developing and comparing several technical alternatives for dealing with the local problem and this emphasis is proper. Interagency and interarea issues should be resolved prior to the technical planning. Other agencies and issues can influence the planning through the problem definition phase; e.g., through the in-stream water quality standards and the wasteload allocation or effluent standards which must be met by the alternative. The facility plan is also subjected to normal environmental impact reviews. Drinking water supplies are one important consideration in establishing these standards and reviewing the plan, but do not necessarily guarantee that all relevant coordination with water supply will occur automatically. Thus it is easy to overlook significant interactions or opportunities for mutual savings which were not identified prior to facilities planning and it is often difficult to make major adjustments during review. Specific finds are:

- There are substantial opportunities during Step 1 facilities planning to achieve improved coordination with water supply including items such as population projections, service area extensions, water use/conservation/wastewater production estimates, water availability, reuse opportunities, and early and continued attention to effluent disposal impacts on downstream and groundwater sources of public supplies.

- One factor which discourages facility planning from seriously developing approaches responsive to a broader range of concerns is the present restriction of Step 2 and 3 funding to only facilities which are physically part of wastewater collection, treatment and disposal works. Even if a change to a downstream water supply would save money on wastewater facilities, construction grants funds could not be used for the change.

- Although significant opportunities for coordination exist in facilities planning and can be further enhanced, much coordination must be accomplished by a more broadly based planning program before facilities planning starts.

2. Coordination Through the Water Quality Management Program

EPA's Water Quality Management (WQM) Program is a consolidated effort under Sections 106, 208 and 303 of the Clean Water Act to address broad water quality issues on state and regional levels through continuing planning and management effort. Although aspects of the program have been difficult to implement, the program now incorporates the most workable planning approach in use by Federal programs: Federal policy direction and sense of priorities are provided together with planning funds but planning is the responsibility of state and local authorities; a mechanism to assure accountability is provided by the emphasis on reviewing planning results and implementation progress through the State-EPA Agreements. In addition, the program is familiar to the public from initial 208 planning, it has broad state and local involvement because it is responsive to state and local concerns, it has developed workable interagency relationships on the state and local level, and a sense of partnership among EPA-state-local institutions is developing. More specific findings are:

- WQM planning provides the most workable vehicle now in existence for recognizing and addressing water quantity/quality interactions and relationships between water supply and wastewater management.

- The program scope which has evolved is strongly oriented toward water quality -- so strongly that it is weak in dealing with water supply or water quantity issues which are interrelated with water quality problems.

- Present unstable and low funding for the program threatens to weaken the continued development of the EPA-state-local planning partnership and to preclude consideration of important water quantity/quality relationships.

3. Municipal Water Conservation

Since municipal water use is relatively small compared to the aggregate use including agriculture and industry, the advantages of conserving municipal supplies are not often apparent. Moreover, recent droughts have highlighted several situations where conservation resulted in increased water rates to the consumer. Recognizing these factors this study emphasized a more comprehensive view of advantages and disadvantages of municipal water conservation, including savings in dollars and energy through delayed capital expenditures. It also emphasized a relatively slow implementation of conservation, where utility water sales might not decrease but instead simply stay constant or grow more slowly. Under these emphases and conservative assumptions, municipal water conservation appears quite attractive. More specific findings are:

- Nationwide implementation of a modest municipal water conservation program over a 15 to 20 year period could result in annual energy savings (primarily from less use of hot water) equivalent to about three percent of present energy imports.

- Even in a community where water conservation causes decreased water sales, the energy savings can pay for needed increases in water rates.

- Municipal conservation is especially attractive for growing communities since expenditures to expand both water supply and wastewater facilities can be postponed with substantial savings in interest and future operating costs.

- Municipal water conservation is on a threshold; it could be widely and enthusiastically received in the next several years if clear and comprehensive information is made available on its overall advantages and disadvantages,and how these vary among regions,so that communities can make informed decisions attuned to their specific situations.

- Improved Federal incentives for municipal water conservation would call attention to its possibilities and help overcome the present inertia in local agencies and consumers.

4. Reuse of Municipal Effluents

Municipal effluents are being directly reused on a widespread and increasing basis, primarily for agricultural and landscape irrigation and for industrial cooling: present direct reuse is approximately three percent of the nation's municipal effluents in the context of more than 536 specific projects, primarily in the water-short areas of the south-central and southwestern states. A significant incentive for municipal reuse was recently provided by the innovative and alternative provisions of the 1977 Clean Water Act amendments which are now beginning to result in 85 percent Federal funding of reuse projects that address clearcut water pollution control needs. Funding policies for reuse projects with indirect water quality benefits are also being considered. One present estimate is that between 10 and 15 percent of municipal effluents might be directly reused for nonpotable purposes by year 2000. More specific findings are:

- The economics of reuse is a major factor which will limit the extent of its implementation. It tends to require costly conveyance and treatment facilities, and to be energy intensive in operation due to pumping, chemical and treatment needs. Alternative supplies or the alternative of doing without additional water supply tends to be strongly competitive economically.

- There are uncertainties on potential health effects associated with various types of direct nonpotable reuse and the degrees of treatment needed to protect against risk. Relaxation of treatment requirements, if this could be demonstrated to be prudent would improve the economic potential of reuse as a function of specific health requirements of the anticipated use.

- Where Federal funding of reuse is to result in indirect water quality benefits such as decreased pollutant loadings on streams (beyond requirements for water quality standards) or increased streamflows (by avoiding new water supply development), there is a danger that these benefits will be lost through other water diversion or development projects.

5. Groundwater Management and Integration with Surface Waters

Groundwater is a source of drinking water for about 103 million people in the U.S., about 47 percent of the total population, and an estimated 95 percent of the rural population. It is usually a relatively dependable source, less costly to develop than surface water, and pure enough for drinking with minimal treatment. Groundwater overdraft or mining is the most common quantity problem: it is estimated that about 20 billion gallons per day, or one-fourth of all groundwater withdrawn, is not replaced by natural or artificial recharge; many aquifers will therefore be exhausted with major problems foreseen in the next ten to twenty years. High salinity concentrations, often a consequence of overdraft, are a dominant groundwater quality problem. More important, however, increased volumes of waste are being handled in ways which can result in groundwater pollution: of great concern are the more than 130,000 surface impoundments of wastewaters, more than 20,000 landfills and more than 40,000 injection wells as well as the many relevant nonpoint sources. Specific findings on groundwater are:

- Recent Federal legislation has provided some tools to begin addressing the threats to groundwater quality posed by wastewater disposal practices. In particular, Underground Injection Control regulations recently proposed will address injection wells. A surface impoundments inventory and assessment is being conducted, and the Resources Conservation and Recovery Act provides a basis for controlling those which contain hazardous wastes. Dumps and landfills will also be controlled under this Act. Both the Sole Source Aquifer provision of the Safe Drinking Water Act and 208 planning under the Clean Water Act provide additional management opportunities. EPA is fully committed to implementing these management tools in cooperation with the states; implementation is now in its preliminary phases. Additional Congressional involvement may be needed as implementation difficulties are encountered.

- Regulation of groundwater mining falls within the authority of the states to establish water law. Many states have no such laws specifically regulating the use of groundwater and where such laws exist, vigor of enforcement varies. Strong special interests tend to resist any effort to more intensively manage groundwater as a fragile resource.

- Both groundwater quality and quantity are neglected by most governmental units in terms of data, analysis, protection from degradation and regulation of use. The interrelationships between quality and quantity aspects of ground and surface waters are usually ignored. Although some political units have addressed groundwater management where water supply is short or the quality of existing supplies is poor, this is the exception. It is expected that groundwater management and integration with surface water programs will be a topic for increasing Congressional attention.

6. Small Water Supply Systems

Approximately 15 percent of the nation's population rely on small community water supply systems which serve at least 25 but less than 10,000 people on a year-round basis. This involves approximately 58,000 distinct small systems or 95 percent of all community water systems in the country. In addition "small systems" include approximately 160,000 noncommunity public systems serving seasonal populations primarily in parks and recreation areas. Approximately 85 percent of the small community systems and 90 percent of the noncommunity systems use groundwater sources. Preliminary national aggregates of incomplete data show that approximately 25 percent of small community systems have violated the microbiological maximum contaminant level (MCL). About 35 percent violated the reporting and monitoring requirement. This compared with 15 percent (MCL) and 25 percent (monitoring) violations for medium to large community systems. Data on compliance/violations are not yet available for noncommunity systems. More specific findings are:

- Although reporting in response to the Safe Drinking Water Act provides solid data on public water system violations of MCLs and monitoring requirements, inventory data are generally unavailable on system characteristics, operating and capital problems, source type, adequacy and reliability, and so forth. This information is particularly sketchy for small systems.

- Violations of drinking water regulations are estimated to be only a symptom of small system problems. Needs for capital improvements, inadequate budgets for operation and maintenance, inadequate operator skills, and inadequate management and planning skills are believed to be very serious problems for the vast majority of small systems.

- Although state and EPA efforts to assist with operator and management training and technical assistance are oriented toward real problems, they tend to reach primarily medium to large systems.

- State supervision programs are unable to adequately assist, inspect, or regulate small systems because of their very large number in relation to available state supervision program resources.

Part 1: ASSESSMENT

Chapter II

EXISTING LEGAL AND INSTITUTIONAL FRAMEWORK

A. Legal/Administrative Overview

1. State Water Law

The right to use water has certain attributes of a property right; how such rights to surface water may be exercised in the United States is determined largely by the historical evolution of the right to the land in connection with which the water is to be used. Generally, the eastern states, having derived their system of property rights from the English common law, apply the "riparian doctrine". Under this concept, as applied when agriculture represented the primary use of land, a landowner adjacent to a water course is entitled to use sufficient surface water to meet his domestic needs and the needs of household animals necessary to his use of his land. The right applies only to water used on land within the watershed from which the riparian derives a claim.

"Riparian rights are incident to ownership of riparian land, are not acquired by use, and are not lost by nonuse" (Corker, 1971). As industrialization occurred, the concept was expanded to allow use of adequate quantities of water for manufacturing, so long as neither the quantity nor the quality of water available to a downstream riparian user was impaired. Damages can be sought from an upstream polluter or surface water user in a judicial proceeding by a downstream user who claims the quality or quantity has been diminished by the upstream user. The judicial remedy is tedious and expensive, however, and often the winner is the party with the most resources and time.

In the western states much of the land was acquired through the Louisiana Purchase (1803), annexation of the Republic of Texas (1845), the Oregon Treaty (1846), the Mexican Cession (1848) and the

Gadsen Purchase (1853) (Myers, 1971). In this region water was often in short supply or even unavailable to support economic activity without storage and distribution systems. The Federal government actively promoted settlement of these acquired lands through legislation favorable to the new settlers. In furtherance of this national policy, special legislation relating to western lands generally recognized state legal systems for surface water allocation (Myers, 1971). Development of available water supplies, utilizing storage reservoirs and distribution systems was subsidized by the Federal government. Subsequent court cases (for example, California Oregon Power Co. v. Beaver Cement Co., 295 US 142 [1935]) not only confirmed the predominance of state appropriative surface water rights systems but also established the concept of Federal "reserved water rights" for land withdrawn from the public domain for a designated Federal purpose (Arizona v. California, 363 US 546 [1963]). In the latter instance, the U.S. government is said to have "reserved" a right to any unappropriated surface water necessary to provide for the development of the land withdrawn, and this right takes precedence over subsequent appropriators under state allocation systems.

There are three essential elements to an appropriative surface water right: (1) "first in time is first in right," thus senior appropriators have superior rights in the event of shortage; (2) the appropriator must use the quantity of surface water for which there is a valid right in a fixed number of years within a stated term (say, 7 out of 10 years) or risk having the right reduced to the volume actually used; and (3) there usually must be a diversion from the watercourse. Whether the holder of a water right is entitled to reuse return flow from the initial use depends upon the legal rule within the authorizing state and whether the initial source, surface or groundwater, is subject to state allocation. There is a trend for states with limited supplies to want to regulate disposition of return flows where the initial use is regulated (Corker, 1971). States sometimes also prescribe a "priority of use" with the intent that a lower priority use can be preempted by a higher one in the event of shortage. For example, the State of Texas code provides the following order: domestic and municipal use, industrial use, irrigation, mining, hydroelectric power, navigation, recreation and pleasure, and "other beneficial uses" (Vernon's Texas Code Annotated).

The seventeen western states -- Washington, Oregon, California, Arizona, Nevada, Utah, Idaho, Montana, Wyoming, Colorado, New Mexico, Texas, Oklahoma, Kansas, Nebraska, South Dakota and North Dakota -- are generally regarded as those with predominately appropriative surface water rights doctrines. Some of these states, however, have "mixed" systems, i.e. some riparian concepts for traditional household and domestic animal uses and the appropriative doctrine for all others. In some cases, Texas for example, riparian right's holders were required by a 1967 statute to convert riparian to appropriative rights. California is just now attempting to reconcile these "two radically different kinds of water rights on a single stream" (Governor's Commission, 1978).

Groundwater is sometimes treated differently from surface water in state law and allocation systems, despite the obvious interdependence between the two. Physical characteristics do provide some complications; for example, groundwater aquifers can intersect and contribute to the flow of more than one surface water basin through underflow and flowing springs. These relationships are further discussed in Chapter V.

The general legal principle initially applied to groundwater was the English common law "rule of capture". A landowner could drill as many wells and pump as much water as he could without waste; he would not be liable in damages to his neighbors for depleting the groundwater supply under their land so long as he applied the water to a "beneficial use". Some state jurisdictions have developed the concept of "safe annual yield" (Corker, 1971) and have provided a system for allocating that volume among users. Other states, such as New Mexico, administer claims to groundwater in much the same manner as appropriative rights to surface water. Where groundwater taking is not restricted to some determinable quantity related to the amount of recharge, however imperfect the methodology for such allocation, there is always the risk of groundwater "mining", i.e. yearly withdrawals that exceed yearly recharge. Mining can occur intermittently because of inadequate rainfall during a drought, or regularly and deliberately as is occurring each year in California as well as in Texas, New Mexico, Oklahoma, Kansas and Colorado where the water level in a prehistoric underground aquifer, the Ogallala, declines each year as massive withdrawals far exceed the minor volume of recharge. Where groundwater mining occurs in coastal or some inland areas there is always the danger of contaminating the remaining supply because of saltwater being drawn into the space previously occupied by the withdrawn freshwater. In these cases, saltwater intrusion is sometimes retarded or prevented by artificial recharge using treated wastewater. A classic example is the recharge project by the Orange County Sanitation District in California.

2. Federal Authority on Water Allocation

Despite the fact that most major (and many minor) water supply projects involve some form of Federal financing or require some type of Federal permit, they normally proceed within the statutory and judicial water rights framework of the state -- or states -- in which they are located. Providing flood control and facilitating navigation have historically been primarily Federal functions with project costs for these purposes borne almost entirely by the public at large. In recent years, one-half the estimated benefits from water based recreation on Federally funded water projects is deducted from project costs, thereby reducing the cost allocated to local project sponsors. Under the Clean Water Act, Section 102 (b), Federal agencies are authorized to give consideration "to inclusion of storage for regulation of streamflow"; the costs of reservoir space for such water quality storage are borne by the public "if the benefits are widespread or national in scope". EPA must determine the need for and value of such storage, but no such positive determination has been made to date.

Most major water supply projects are constructed by agencies of the Federal government using tax revenues appropriated by the Congress with certain costs reimbursable by the beneficiaries; water rights for these projects are secured and held by local sponsors or by states. The Federal construction agencies -- the Corps of Engineers, the Bureau of

Reclamation and the Soil Conservation Service -- do not apply for, nor do they hold, permits or rights for the allocation of water in the reservoirs although they construct and operate them until the non-Federal cost share is repaid or the Federal interest fulfilled. Their arrangement with the water users is a contractual one as prescribed by the Congress in authorizing legislation.

The Federal "reserved rights" to water previously mentioned are restricted to the Federal lands withdrawn from the public domain for national forests and parks, historical monuments, military installations and Indian and other reservations. These water rights are based upon the principle that "when public lands are withdrawn or reserved from the public domain, quantities of the then unappropriated water necessary to fulfill the purposes for which the land is withdrawn are also reserved and exempted from appropriation under state laws. As a result, an Indian or Federal reservation acquires reserved water rights which vest on the date the reservation was created and are superior in right to future appropriations under state law (Comptroller General, November 16, 1978). Not all these rights have been quantified and those unresolved Indian and other reservation water claims represent a unknown demand upon state administered water rights systems. The Federal involvement in Indian rights exists because of the position of the Bureau of Indian Affairs within the Department of Interior and its role as the trustee of Indian interests.

Federal agency water resource planning, to the extent that it determines hydrologically the available surface or groundwater quantity and quality, can influence water allocation by the states. Where there is no competing state or local water resource planning capability, the Federal agencies can have significant impact; they do not, however, except indirectly, significantly influence state water rights systems.

Where water allocation becomes an interstate or international question, the Congress does exercise some influence on water availability. Interstate compacts are subject to Congressional approval; where these allocate water as between the states, Congress must approve the allocation in the process of approving the compact. While only the affected states are normally represented on the Compact Commission (as with the Ohio River Sanitation Commission), the compact may specify a Federal representative (as with the Delaware River Basin Commission). For the northern U.S. boundary with Canada, the United States representative on the International Joint Commission is named by the President; the IJC can impact both water quantity and water quality in the states along the border where water courses and water bodies are shared by the two nations. The International Boundary and Water Commission has been extensively involved in both quantity and quality issues as they have arisen on two major rivers shared with Mexico -- the Colorado and the Rio Grande. While not all the Nation's geography is included within River Basin Commissions authorized under the Water Resources Planning Act of 1965, as amended, some of these have impacted interstate regional water quantity and quality planning -- the New England River Basin Commission and the Missouri River Basin Commission, for example. These Commissions do provide a forum in which interstate differences can be aired.

3. Federal Water Quality Law

Federal activity in the water quality field was initiated with a modest program in 1948 and culminated in the detailed 1972 and 1977 Federal Water Pollution Control Act and Clean Water Act. The national program began within the Department of Health, Education and Welfare as an adjunct to the concern for public health, proceeded to the Department of Interior in 1966 by Executive Reorganization Act Order and was again transferred to its current location within the Environmental Protection Agency by Executive Order in 1970. Because there developed a general consensus within the Congress that states were not proceeding aggressively enough to correct water pollution, the Federal role was gradually expanded with the most dramatic changes occurring between 1965 and 1972. In the latter year, Congress also shifted the regulatory system from one based on ambient water quality standards for interstate waters (enforced by a lengthy conference process with appeal to court available on a trial de novo basis) to a combination of technology-based and water quality standards-related limitations on effluent incorporated into Federal permits for every discharger of wastewater into any of the Nation's waters (with direct Federal enforcement where states fail to take action after a reasonable time). The Federal role is now predominant; however, the EPA is in the process of negotiating with all states hoping to arrive at "State-EPA Agreements" that will contractually obligate the states to perform as many as possible of the environmental regulatory functions Congress assigned to EPA, including those under the Clean Water Act. Specific Federal statutory authority exists for assignment to the states of administration of construction grants for publicly owned treatment works (POTWs) and the national pollution discharge elimination system (NPDES) permits.

Regarding drinking water quality, prior to 1974, the Federal role was limited -- i.e., the EPA was authorized to prescribe Federal drinking water standards only for water supplies used by interstate carriers. With passage of the Safe Drinking Water Act in 1974 EPA is now authorized to establish Federal standards to control the levels of all harmful contaminants in the drinking water supplied by public water systems. It also establishes a joint Federal-state system for assuring compliance with these standards. The primary drinking water standards, proposed secondary standards, and other EPA actions undertaken or pending in response to the Act are discussed extensively in Chapter IV.

4. State Water Quality Law/Administration

Despite the dominant Federal role prescribed by Congress in the national water pollution control program, the states perform significant implementing functions, particularly in construction grants, enforcement and the development of ambient water quality standards, which are still part of the Federal program. Many states have reorganized their administrative agencies to duplicate the Federal Environmental Protection Agency. Between 1967 and 1974, 32 major state reorganizations occurred (National Commission on Water Quality, 1975). Twelve states mirrored the Federal EPA and fifteen states created environmental super agencies encompassing some of the state's natural resource management and/or conservation functions as well as environmental regulation. Sixteen states included pollution control in their health departments.

States can adopt, and the EPA approve, water quality standards so high that more stringent treatment requirements than the minimum prescribed by EPA under the Clean Water Act are necessary. In those areas where such standards are in effect, POTWs may have to provide advanced waste treatment (AWT) which is more expensive than treatment necessary to conform to minimum EPA requirements. These projects are still eligible for 75 percent of Federal funding, although they require personal approval of the EPA Administrator pursuant to an October 1978 directive of the Appropriations Conference Committee.

B. Institutional Overview

1. Water Supply

While the need for municipal water is local, all but the simplest projects often involve Federal -- and sometimes state -- agencies as well. Surface water supply reservoirs and wholesale distribution systems can be constructed by the Soil Conservation Service of the Department of Agriculture, the Bureau of Reclamation of the Department of Interior and the Army Corps of Engineers of the Department of Defense depending upon size and geographical placement. Soil Conservation Service reservoirs are limited to 25,000 acre feet of total storage of which no more than 12,500 acre feet can be flood detention leaving the same maximum quantity for all other uses, one of which can be municipal water supply. Operations of the Bureau of Reclamation are restricted generally to the geographical area west of the 100th meridian; municipal water supply projects in that area are usually constructed by the Bureau, while those east of that line are usually built by the Corps.

Two agencies within the Department of Interior provide information or influence the formulation of municipal water supply plans. The U.S. Geological Survey (USGS), obtains and publishes national water quantity and quality data, sometimes through joint USGS-State-local financing. The U.S. Fish and Wildlife Service analyzes the potential effect of proposed projects upon fish and wildlife resources and can initiate actions leading to mitigation requirements to minimize adverse effects. The cost of these measures is borne by the water users.

Federal financial assistance for municipal water supply is available from the Department of Housing and Urban Development (HUD), the Economic Development Administration (EDA), the Bureau of Reclamation, the Farmers Home Administration (FmHA), the Soil Conservation Service (SCS) and the Small Business Administration (SBA). When water supply for a local community or city is included in a Federal water project constructed by the Bureau or the Corps, initiating repayment of the local share of the cost can be postponed for certain statutory periods; interest costs for money needed to pay expenses during construction are borne by the national taxpayers. The type and terms of Federal assistance programs are discussed in Chapter VI as are State financial assistance programs.

Two Federal agencies review many Federal surface water supply projects designed to meet municipal needs -- the Water Resources Council (WRC) and the Council on Environmental Quality (CEQ). The former is responsible for developing and updating "Policies, Standards, and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources" as well as formulation, with the Department of Commerce, of the national data base and procedure for economic projections upon which population projections and water needs can be estimated. The CEQ oversees the requirement for preparation of environmental impact statements (EIS) by every Federal department or agency contemplating legislation or other major Federal action significantly affecting the human environment.

Water supply projects that involve some Federal interest are subject to Congressional authorization and appropriation as well as changes in Presidential policies. Thus, years can be consumed from conception to fruition; a moderately sized reservoir can take 10 to 20 years. Constructing such projects without Federal involvement might shorten the time, but the local cost would, in most cases, be higher because of the cost benefits provided under Federal law.

Reservoirs constructed by Federal agencies are operated by those agencies during the pay-back period and to achieve any Federal purpose; operating conditions are fixed by Congress upon recommendation of these agencies and tend to be inflexible. Rarely can a series of reservoirs constructed at different times under individual legislative mandates be operated as a system to achieve optimum water conservation and use without special legislation.

2. Wastewater Treatment

Federal participation in the funding of POTWs through grants administered by EPA under the Clean Water Act are now at 75 percent of eligible costs for traditional treatment systems and 85 percent for "treatment works...utilizing innovative or alternative wastewater treatment processes and techniques referred to in section 201(g)(5)..." (Clean Water Act, 1977). Federal funds have been provided since 1957, but the amount never exceeded 250 million dollars yearly until 1970. Prior to the substantial increase in the Federal percentage in 1972, the degree of Federal participation was increased if states also assisted with funding. In addition to EPA, the FmHA has a grant and loan program for the construction of wastewater collection and treatment systems in rural areas and HUD makes grants to cities for sanitary sewer systems but not for treatment works. Federal and State financial assistance is further discussed in Chapter VI.

Under the Clean Water Act, physical facilities for wastewater treatment were intended to be in conformity with "areawide waste treatment management plans" prepared by designated planning agencies, certified by State Governors and approved by the EPA under Section 208. Because of the time required to initiate the 208 program and erratic availability of construction grant funds, these two activities have generally proceeded in reverse order -- treatment plants planned, designed and constructed followed by development of 208 plans. Facilities plans are also required as an integral part of each construction grant application under Sections 201 and 203 of the Act. In addition, "Level B" basin plans described in the Water Resources Planning Act are required to be prepared under the auspices of the WRC by January 1, 1980 under Section 209 of the Clean Water Act, and each state is required to maintain "a continuous planning process" to assure compliance with the Act under Section 303(e). Publicly owned treatment works are also required to comply with these plans. As of June 1979 EPA has developed proposed regulations for Water Quality Management Planning consolidating many of its planning programs as will be further discussed in Chapter IV.

3. Executive and Legislative Demands

Both Federal water supply and wastewater treatment works construction programs are subjected to extensive review by various Committees of the Congress. In addition to the appropriation process and oversight, and to investigative and government operations committees in both Houses of Congress, the responsible agencies report to a diverse group of committees. A water supply project may fall within the purview of House Committees on Banking, Finance and Urban Affairs; Public Works and Transportation; Interior and Insular Affairs or Agriculture and the Senate Committees on Banking, Housing and Urban Affairs; Environment and Public Works; Energy and Natural Resources and Agriculture, Nutrition and Forestry, depending upon the source of funding. Wastewater treatment construction grant programs are within the jurisdiction of all the same committees except House Interior and Insular Affairs and Senate Energy and Natural Resources.

Even after the form of these various programs has been specified and the money appropriated by these Committees in both Houses, and differences resolved by Conference Committees, the President can control the actual expenditure of funds through the Office of Management and Budget (OMB). This same staff also reviews the various programs through the executive budgeting process.

In recent years, the Comptroller General also has exerted an increasing influence in the program review process. He responds to Congressional requests regarding review of the grants program process and also performs legislative reviews under his own initiative.

C. President's Water Policy

In his environmental message sent to Congress on May 23, 1977, President Carter directed the OMB, WRC and CEQ to initiate, under the Chairmanship of the Secretary of Interior, a review of Federal water policy and make recommendations for change. Various proposals were presented by the WRC through publication in the Federal Register on July 15, and 25, 1977, for discussion at hearings to be held throughout the country. This review process culminated in the President's Water Policy Message sent to Congress on June 6, 1978. Among the proposals were the following relating to water supply and wastewater treatment:

- "A directive to the Water Resources Council to improve implementation of the Principles and Standards governing the planning of Federal Water projects... to provide "equal emphasis" to national economic development and environmental quality..."
- "(Improve)... the Principles and Standards... by adding water conservation as a specific component of both the economic and environmental objectives..."
- "Projects should stress water conservation..."
- "Funding for mitigation of fish and wildlife damages should be provided concurrently and proportionately with construction funding..."
- "For project purposes with vendible outputs (such as water supply...), States would contribute 10 percent of the costs, proportionate to and phased with Federal appropriations. Revenues would be returned to the States proportionate to their contribution.
- "Making appropriate community water conservation measures a condition of the water supply and wastewater treatment grant and loan programs of the Environmental Protection Agency, the Department of Agriculture and the Department of Commerce;
- "Integrating water conservation requirements into the housing assistance programs of the Department of Housing and Urban Development, the Veterans Administration and the Department of Agriculture;

- "Requiring development of water conservation programs as a condition of contracts for storage or delivery of municipal and industrial water supplies from federal projects;...

- "Require that new and renegotiated contracts include provisions for recalculation and renegotiation of water rates every five years;

- "Preparation of legislation to provide $25 million annually in 50%-50% matching grant assistance to States to implement water conservation technical assistance program;

- "Proposing a substantial increase from $3 million to $25 million annually in the funding of State water planning under the existing 50%-50% matching program administered by the Water Resources Council...;

- "A directive to Federal agency heads to provide increased cooperation with States and leadership in maintaining in-stream flows and protecting groundwater..." (Federal Water Policy, 1978).

The President charged Secretary Andrus, Secretary of Interior, "with the lead responsibility to see that these initiatives are carried out promptly and fully" (Federal Water Policy, 1978). Nineteen task forces were created with "175 representatives from the Departments of Interior, Agriculture, Housing and Urban Development, and the Army, Water Resources Council, Environmental Protection Agency and General Services Administration" (Environment Reporter, November 1978). Workshops were conducted during March 1979 to consider preliminary reports from "10 of the 19 Federal interagency task forces (ibid, February 1979); and final reports are due in June, 1979 (ibid, December 1978).

Meanwhile, on January 4, 1979, the President by Executive Order (No. 12113, 44FR 1955) directed that preauthorization reports, proposals and plans "be submitted to the Water Resources Council for review by the Council to assure compliance with current principles, standards and procedures for planning and evaluating such projects (ibid, January 1979). Interagency agreements have also been executed between EPA and the Department of Interior, as authorized by Section 304(j) of the Clean Water Act (ibid, December 1978), and between EPA and the Department of

Agriculture (ibid, January 1979) to provide better coordination between environmental, water quality and water quantity issues among these agencies.

Two analyses of the President's proposed policies have already been completed for the Congress. One (Library of Congress, 1978) lists five problems "relative to institutions": (1) water subsidies which provide "competitive advantages of uses such as irrigation, navigation, and recreation over other uses and values"; (2) "impairment of environmental values by water-related laws and management"; (3) "groundwater and surface water interrelationships"; (4) "inflexibility in water allocation and use;" and (5) "lack of access for public involvement in water programs." Another (Comptroller General, 1978b) criticized some of the President's suggestions: (1) "Wastewater treatment construction projects use a large portion of the Federal water budget, but the Environmental Protection Agency (EPA) is not required to economically justify them under the (Water Resources Council) principles and standards...we still believe their costs should be justified in terms of expected benefits..."; (2) "WRC includes the Secretaries of the Departments under which the water resources agencies are located and is chaired by the Secretary of the Interior; therefore, WRC is not independent of member agencies' influence..."; (3) "there are, however, cost sharing inconsistencies and inequities which the policy did not address--including the many variations in cost sharing requirements of the various Federal water resource programs;".

The National Governor's Association responded to discussion of proposed new policies in February 1978 by adopting 11 principles:

"1. States have primary responsibility for water management.

"2. The proper federal role is to establish a framework of national objectives and to assist states in the development of programs to meet those objectives.

"3. Water management should be more comprehensively approached at all government levels.

"4. Federal actions must be consistent with state and interstate water plans and programs.

"5. There must be continuity in federal support for water management programs.

"6. Greater flexibility in the federal support system for water management is needed.

"7. Criteria for federal water program and project evaluation should be refined and uniformly applied.

"8. Financing, cost-sharing, and cost recovery policies should be revised to eliminate inequities toward water problem solutions and to promote equal consideration of structural and nonstructural alternatives.

"9. Water conservation must be a fundamental consideration.

"10. Federally supported water research should be expanded and made more responsive to state concerns.

"11. Indian and Federal reserve water rights claims should be initially addressed within the framework of state legal systems" (Committee on Natural Resources and Environmental Management, 1978).

A Council of State Governments (November 1978) publication listed as "Problems and Issues": water scarcity, groundwater losses (mining), surface water pollution and groundwater contamination, Federal reserved rights, competing demands between energy and agriculture for water in the Western states, cost sharing, institutional reform, concern that conservation measures would reduce water from existing projects for irrigation, and a Presidential (Executive) bias against water projects. After discussing these various problems, the report concludes:

"While it is reasonable for the states to insist that the rhetoric of partnership be translated into open communication and balanced cooperation between the states and federal agencies, the states should themselves improve their policy and management processes...To win a more responsible role in determining national water policy administration, states should convince environmental protection interests that environmental quality will not be sacrificed if states gain a stronger role in national water policy...they should be persuaded that the alternative to centralized government solutions offered by Congress and federal agencies is the possibility of innovation, the sensitivity to local conditions, and the responsiveness to local preferences that is represented in the states...Through strengthening their own organizations and management capacity, and playing an effective role in multistate institutions dealing with regional issues, the states can reduce the threat of federal interference and intrusion. However, any realistic appraisal of the nation's water problems would suggest that there is a substantial role for the federal government. The basic issues are national and are an integral part of national economic, environmental, urban, agricultural, and energy policies..."

As to conservation initiatives, (1) they were supported, but "our broader recommendations and matters we identified for further study have not yet been adequately addressed"; (2) enhanced Federal-State cooperation in water management was commended, but "we believe consideration should also be given to the benefits of establishing a clearinghouse to support the conservation grant program..., and of establishing policy guidance on the federal role in solving the emerging urban water supply problems"; and (3) "the issue of water quality was not adequately addressed" (Controller General, November 6, 1978).

D. Summary/Findings

Under existing institutional arrangements and Federal-state-regional-local government policies, the following emerge as problem areas:

- Efficient operation of Federal reservoirs in a watershed as a unified system is often precluded because they are built by different agencies with differing operating requirements set by Congress.

- Quantitative and qualitative analyses of groundwater, regulation of its use and its protection from degradation have been neglected by most political units except where water supply is short or the quality of existing supply is poor.

- The interrelationships and interdependence between the quantity and quality of groundwater and surface water is too often ignored in water quantity allocation and water quality protection systems.

- Available surface waters are sometimes committed to present demands without regard to future drinking water supplies.

- Allocation of some streamflow to in-stream uses such as water quality and fish and wildlife maintenance has received low priority in the past; if these uses are to be accorded higher priority in the future, major adjustments to institutional mechanisms will be required.

- Coordination of water quantity and water quality planning at any governmental level often requires time-consuming interagency cooperation under pressure from above with indifferent results unless, as is rarely the case, a single agency is responsible for both functions at the state, regional or local level.

- Water supply and wastewater treatment projects are separately planned, financed and constructed by different agencies under different statutes and regulations to achieve different purposes without regard to their interacting effects or possible mutual savings or advantages.

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Chapter III

THE AVAILABLE WATER RESOURCE AND ITS USE

A. National Availability

The conterminous U.S. receives an average of 30 inches of rain annually. About two-thirds of this water is evaporated to the atmosphere from lakes, streams, and swamps or transpired by vegetation as is illustrated in Figure 3.1. The remaining 10.3 inches becomes either streamflow (6.4 inches) or recharge for the Nation's groundwater (3.9 inches). About 2.7 inches of the groundwater accretion goes to shallow aquifers which sustain the Nation's streams during dry periods so that, in the end, some 9.1 inches of surface streamflow is observed and only 1.2 inches reaches the deep aquifers (WRC, 1978a).

The 10.3 inches or 1450 billion gallons per day (bgd) of surface flow and groundwater recharge constitute the freshwater resource of the conterminous states. Under current ("1975") conditions of use, 9.3 inches flows to the oceans or adjoining countries (8.6 inches as streamflow and 0.7 inches as sub-surface flow from groundwater), 0.1 inch evaporates from reservoirs, and the remaining 0.9 inches is consumptively used.

Development and use of the full 1450 bgd is neither possible nor desirable. Variations in precipitation create periods of floods and droughts. Only if all flood flows could be stored for use in future dry years would it be physically possible to utilize all of this water. With existing storage reservoirs the U.S. Water Resources Council (WRC, 1978a) estimates that only about 675 bgd can be considered to be available in 95 out of 100 years. In other words if the Nation attempted to develop and consume 675 bgd, water shortages would be expected in one year out of twenty.

The "usable resource" (675 bgd) can be increased by providing additional storage but not to the full amount of the "natural supply"

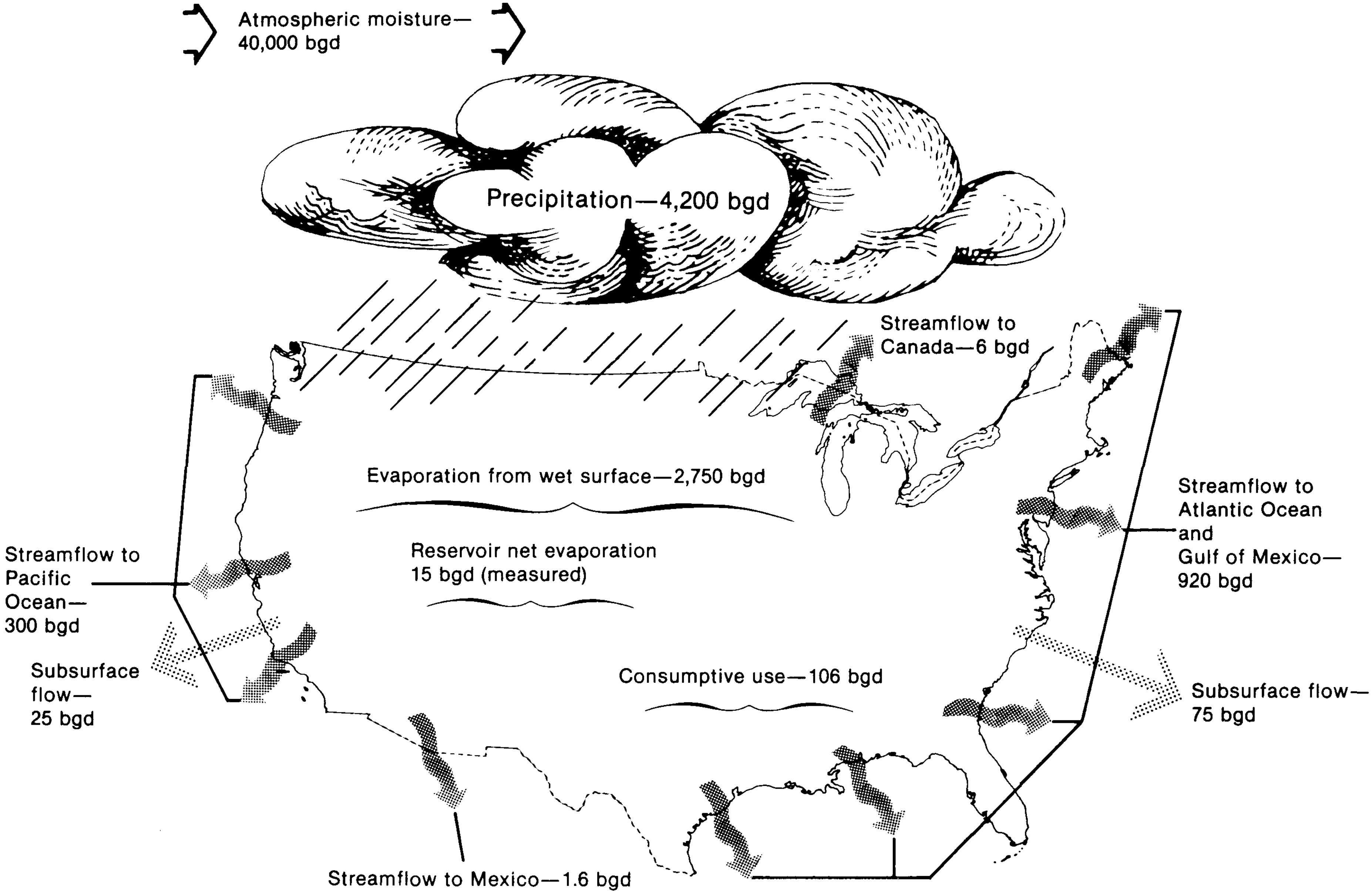


Figure 3.1 WATER BUDGET OF THE CONTERMINOUS UNITED STATES, "1975" CONDITIONS

Source: WRC (1978a)

(1450 bgd). In some regions the necessary reservoir sites are not available, in others the great increase in reservoir surface area required would result in substantial depletion of the available water by evaporation. Additional storage would also be increasingly costly and, at some point, would be economically infeasible.

In addition to the physical and economic reasons which preclude full development of the natural supply, the approximately 100 bgd of groundwater outflow to the oceans and the 8 bgd of surface flow to Canada and Mexico is largely unavoidable. It is also essential to leave considerable flow in the streams to support aquatic life, wildlife and riparian vegetation, permit recreational use and navigation, and maintain scenic values. Finally surface flow must also be permitted to reach the oceans to maintain conditions in estuaries suitable for the marine life which begins its life cycle there, and to prevent intrusion of salt water to the water intakes of many coastal cities. While it is not possible to state exactly the amount of water which can be considered as a "usable" resource, it is greater than the 675 bgd estimated for 1975 conditions but less than the 1450 bgd of natural supply.

The preceding discussion of the water resource has considered the conterminous 48 states as a whole. Table III-1 summarizes the mean natural supply for all water resource regions shown in Figure 3.2, including 18 in the conterminous states and the Alaska, Hawaii and Caribbean Islands regions. It is noteworthy that Alaska alone has a mean annual supply equal to three-fouths that of the conterminous states. Table III-1 also presents estimates of the flows at various probability levels. Percent exceedance equals the number of years per century in which the indicated flows will be equaled or exceeded. For example, on the average, a total flow for all WRC regions of 2119.7 bgd will be equaled or exceeded in 50 out of the 100 years.

Groundwater poses a special assessment problem. As indicated in the preceding discussion of the national water balance, annual accretion to groundwater is estimated at 3.9 inches of which 2.7 inches are discharged to the streams and included in the summary of surface water

Table III-1

STREAMFLOW FREQUENCY - "1975"

Water resources region and No.	Streamflow, in billion gallons per day				
	Mean	Percent exceedance			
		5	50	80	95
New England (1)	78.2	107.7	77.4	62.7	48.3
Mid-Atlantic (2)	79.2	115.1	77.8	61.2	48.4
South Atlantic-Gulf (3)	228.0	356.6	219.3	164.1	121.8
Great Lakes (4)	72.7	103.9	71.7	57.3	44.9
Ohio (5)	*178.0*	*254.0*	*178.0*	*141.0*	*105.0*
Tennessee (6)	*40.8*	*57.9*	*40.8*	*35.9*	*31.4*
Upper Mississippi (7)	*121.0*	*189.0*	*121.0*	*91.8*	*65.3*
Lower Mississippi (8)	433.0	757.0	433.0	282.0	202.0
Souris-Red-Rainy (9)	6.0	11.4	5.6	3.4	1.8
Missouri (10)	*44.1*	*74.3*	*43.2*	*29.9*	*17.6*
Arkansas-White-Red (11)	*62.6*	*120.7*	*59.1*	*37.4*	*21.6*
Texas-Gulf (12)	28.3	62.4	22.9	12.3	6.3
Rio Grande (13)	1.2	4.4	.6	.3	.2
Upper Colorado (14)	*10.0*	*15.6*	*10.0*	*7.0*	*3.9*
Lower Colorado (15)	1.6	1.7	1.6	1.4	1.2
Great Basin (16)	2.6	4.7	2.4	1.6	1.2
Pacific Northwest (17)	255.3	344.7	254.3	213.3	179.7
California (18)	47.4	87.4	44.3	29.8	19.5
Total, Regions 1-18	1,233.4	1,956.9	1,210.9	889.4	675.3
Alaska (19)	905.0	1,030.0	898.0	795.0	705.0
Hawaii (20)	6.7	10.3	6.3	4.9	3.8
Caribbean (21)	4.9	7.1	4.5	3.3	1.6
Total, Regions 1-21	2,150.0	3,004.3	2,119.7	1,692.6	1,385.7

(italic numbers not included in total because these are inflows to another region)

Source: WRC (1978a)

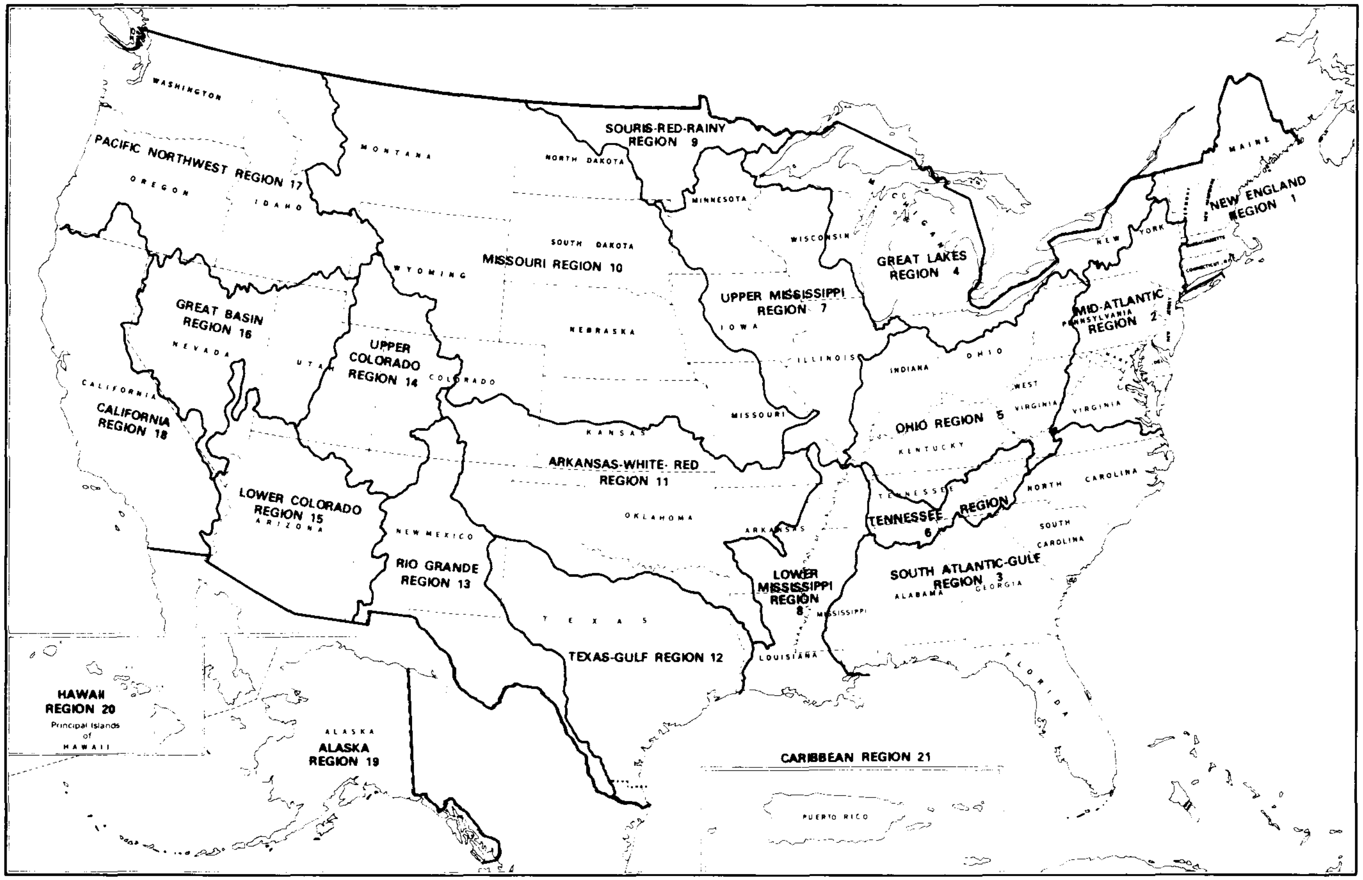


Figure 3.2 WATER RESOURCES REGIONS

Source: WRC (1978a)

availability in Table III-1. Another 0.7 inch flows to the ocean leaving only 0.5 inch of average annual recharge. The total volume of groundwater underlying the U.S. has been estimated at 50 times the annual surface runoff. This water has accumulated over centuries, particularly in the arid regions of the west. Withdrawals at a rate exceeding the recharge can result in rapid depletion of the stored water. For example in the High Plains of west Texas the small amount of rainfall results in an annual recharge which has been estimated at about one-quarter inch. The use of 36 inches annually for irrigation represents a withdrawal of water which may have taken nearly 150 years to accumulate. Water levels are dropping rapidly and continued depletion could soon force much land out of production (National Water Commission, 1973).

Hence, while the Nation's groundwater reserves are large, local exhaustion is occurring as a result of "mining" just as it does for petroleum or minerals. To specify the "available" groundwater at an average annual rate in the same way as for surface water requires a decision as to the acceptable rate of mining. The safe yield without depletion of reserves is equal to the average recharge of 0.5 inch or about 60 bgd. As indicated in Table III-2 approximately 81 bgd was withdrawn in the conterminous states in 1975 which means that safe yield is being exceeded by 35 percent. If a national decision is made that some groundwater can be mined without serious problems of depletion, then the "available" groundwater is an equivalent amount more than the 60 bgd (Linsley, 1979).

B. Present and Projected Use

1. "Offstream" Water Use

Trends in freshwater use by diversion from streams or groundwater are shown by functional category in Figure 3.3 and are summarized in Table III-3. Total withdrawals of freshwater in 1975 were 338 bgd. Only about 107 bgd of this water was consumed. An additional 60 bgd of saline water was withdrawn from estuaries and the ocean mostly for cooling water. The WRC projects that total withdrawals will decline as a result of improved efficiency of use in industry, agriculture and

Table III-2

GROUNDWATER WITHDRAWALS AND PERCENTAGE OF OVERDRAFT: "1975"

Water resources region and No.	Total withdrawal (mgd)	Overdraft		Subregions		
		Total (mgd)	Percent	Number in Region	Number with Overdraft	Range in overdraft (percent)
New England (1)	635	0	0	6	0	----
Mid-Atlantic (2)	2,661	32	1.2	6	3	1- 9
South Atlantic-Gulf (3)	5,449	339	6.2	9	8	2-13
Great Lakes (4)	1,215	27	2.2	8	1	30
Ohio (5)	1,843	0	0	7	0	----
Tennessee (6)	271	0	0	2	0	----
Upper Mississippi (7)	2,366	0	0	5	0	----
Lower Mississippi (8)	4,838	412	8.5	3	3	7-13
Souris-Red-Rainy (9)	86	0	0	1	0	----
Missouri (10)	10,407	2,557	24.6	11	10	4-36
Arkansas-White-Red (11)	8,846	5,457	61.7	7	7	2-76
Texas-Gulf (12)	7,222	5,578	77.2	5	5	24-95
Rio Grande (13)	2,335	657	28.1	5	4	22-43
Upper Colorado (14)	126	0	0	3	0	----
Lower Colorado (15)	5,008	2,415	48.2	3	3	7-53
Great Basin (16)	1,424	591	41.5	4	4	7-75
Pacific Northwest (17)	7,348	627	8.5	7	6	4-45
California (18)	19,160	2,197	11.5	7	5	7-31
Regions 1-18	81,240	20,889	25.7	99	59	1-95
Alaska (19)	44	0	0	1	0	----
Hawaii (20)	790	0	0	4	0	----
Caribbean (21)	254	13	5.1	2	1	5
Regions 1-21	82,328	20,902	25.4	106	60	1-95

Source: WRC (1978a)

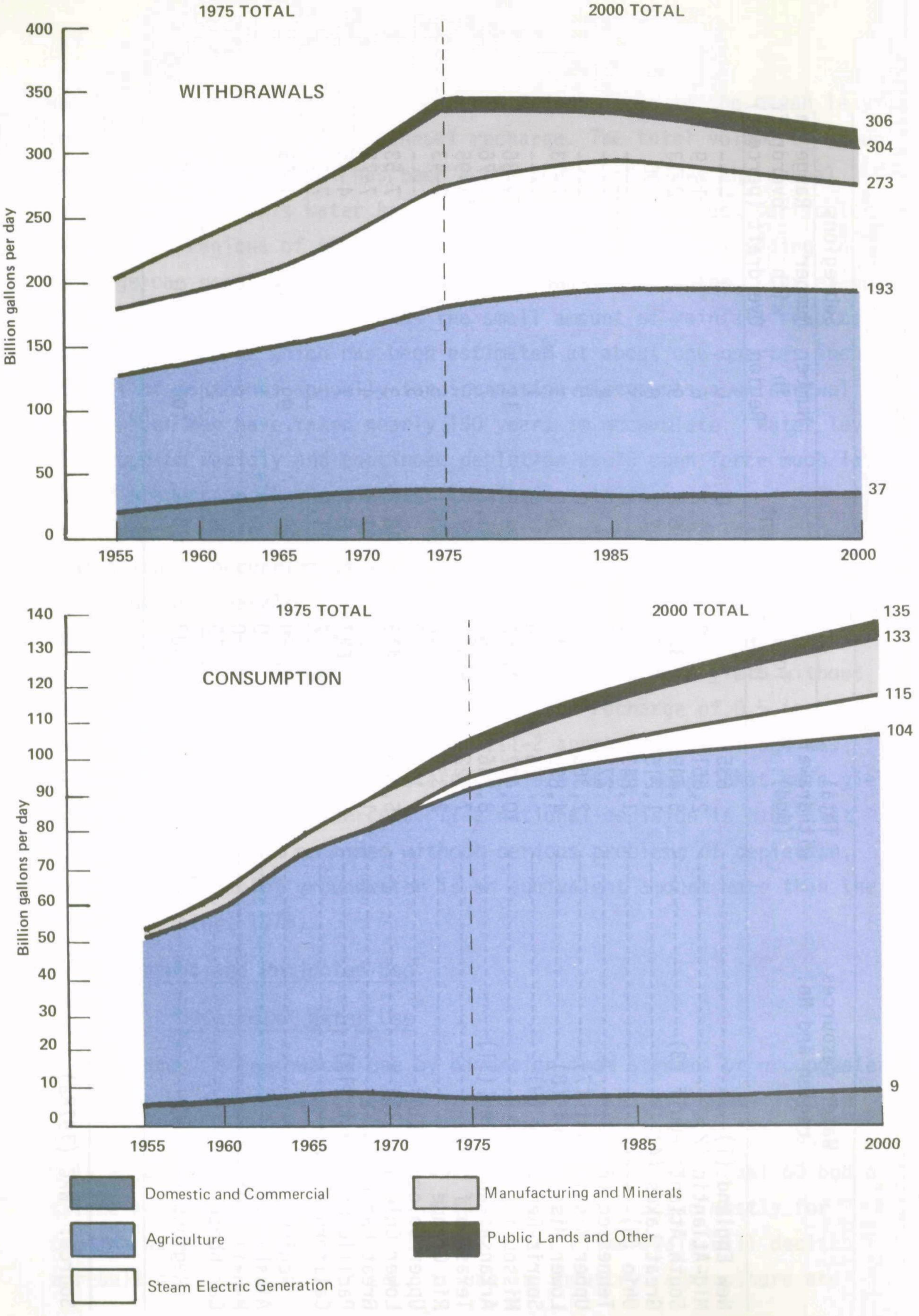


Figure 3.3 TOTAL FRESHWATER WITHDRAWALS AND CONSUMPTION BY FUNCTIONAL USE

Source: WRC (1978a)

TABLE III-3

TOTAL FRESH WATER WITHDRAWALS AND CONSUMPTION, BY FUNCTIONAL USE, FOR THE 21 WATER RESOURCES REGIONS: "1975," 2000

(million gallons per day)

	Total Withdrawals		Total Consumption	
Functional Use	"1975"	2000	"1975"	2000
Fresh Water:				
Domestic:				
Central (municipal)	21,164	27,918	4,976	6,638
Noncentral (rural)	2,092	2,400	1,292	1,436
Commercial	5,530	6,732	1,109	1,369
Manufacturing	51,222	19,669	6,059	14,699
Agriculture:				
Irrigation	158,743	153,846	86,391	92,506
Livestock	1,912	2,551	1,912	2,551
Steam electric generation	88,916	79,492	1,419	10,541
Minerals industry	7,055	11,328	2,196	3,609
Public lands and others[a]	1,866	2,461	1,236	1,731
Total Fresh Water	338,500	306,397	106,590	135,080
Saline water, total	59,737	118,815		
Total Withdrawals	398,237	425,212		

a. Includes water for fish hatcheries and miscellaneous uses.

Source: WRC (1978a)

steam electric generation. Actual consumption is expected to increase about one-fourth, with the largest increases in the same sectors -- industry, agriculture and steam electric generation.

The distribution of the present withdrawals among the water resources regions is indicated in Table III-4. Note that water use in Alaska, Hawaii, and the Caribbean constitutes only a small portion of the above totals.

Domestic and commercial withdrawals, which include most drinking water, are about 29 bgd and are expected to increase to 37 bgd in 2000. Consumption by these uses is about 7 bgd and is projected to be 9 bgd. Obviously, domestic and commercial water needs are small compared to other uses. For example, agriculture is responsible for about 47 percent of fresh withdrawals and 83 percent of consumption.

Changes in projected use result from population growth and other factors. Conversion of WRC information on present and projected off-stream freshwater use to a per capita basis (WRC, 1978b) provides the following insights:

- The WRC has assumed per capita domestic and commercial withdrawals and consumption will remain constant, in spite of the trend for increase shown by data from the past two decades. (Murray and Reeves, 1977).

- Irrigation water use per capita is projected to decrease both for withdrawals (22 percent) and consumption (14 percent). This is due to: (1) the lack of new, economical irrigation water sources to keep pace with population growth; (2) anticipated loss of irrigation water sources where excessive groundwater mining is now occurring; (3) expected increases in agricultural yields; and, (4) increased efficiency in irrigation practices. Increased irrigation efficiency is projected to result in decreases of both water withdrawal (15 percent) and water consumption (5 percent) on a per irrigated acre basis.

- Steam electric water use per capita is projected to have a 27 percent decrease in withdrawals but a 460 percent increase in consumption. These changes are due to: (1) a projected increase in per capita electricity generation of 300 percent; (2) extensive recycling of cooling water through cooling ponds and towers; and, (3) an increase in water consumption of 50 percent due to recycling.

Table III-4

TOTAL FRESH- AND SALINE-WATER WITHDRAWALS: "1975"

Water resources region and No.	Withdrawals, in million gallons per day				
	Fresh water			Saline water	Total
	Surface	Ground	Total		
New England (1)	4,463	635	5,098	5,216	10,314
Mid-Atlantic (2)	15,639	2,661	18,300	19,625	37,925
South Atlantic-Gulf (3)	19,061	5,449	24,510	7,460	31,970
Great Lakes (4)	41,598	1,215	42,813	0	42,813
Ohio (5)	33,091	1,843	34,934	0	34,934
Tennessee (6)	7,141	271	7,412	0	7,412
Upper Mississippi (7)	10,035	2,366	12,401	0	12,401
Lower Mississippi (8)	9,729	4,838	14,567	1,253	15,820
Souris-Red-Rainy (9)	250	86	336	0	336
Missouri (10)	27,609	10,407	38,016	0	38,016
Arkansas-White-Red (11)	4,022	8,846	12,868	0	12,868
Texas-Gulf (12)	9,703	7,222	16,925	9,163	26,088
Rio Grande (13)	3,986	2,335	6,321	0	6,321
Upper Colorado (14)	6,743	126	6,869	0	6,869
Lower Colorado (15)	3,909	5,008	8,917	0	8,917
Great Basin (16)	6,567	1,424	7,991	0	7,991
Pacific Northwest (17)	30,147	7,348	37,495	131	37,626
California (18)	20,476	19,160	39,636	14,569	54,205
Total, Regions 1-18	254,169	81,240	335,409	57,417	392,826
Alaska (19)	261	44	305	57	362
Hawaii (20)	1,089	790	1,879	1,139	3,018
Caribbean (21)	653	254	907	1,124	2,031
Total, Regions 1-21	256,172	82,328	338,500	59,737	398,237

Source: WRC (1978a)

- Manufacturing water use per capita is projected to have withdrawals decrease by 69 percent but consumption increase by 96 percent. These changes are due to: (1) an increase in per capita manufacturing production of 100 percent; (2) a slight shift to less water consumptive manufacturing processes or products; and, (3) extensive recycling of water in manufacturing processes.

In summary, the most significant changes expected appear to be due to increased efficiency in agriculture and increased per capita demand for electricity and manufactured goods.

2. In-Stream Uses

The extent to which the water resource in the streams is being "used" is difficult to quantify. In-stream uses include water needed for fish and wildlife, recreation, hydroelectric power, waste assimilation, navigation, freshwater flow to estuaries, maintenance of riparian vegetation and floodplain wetlands, and conveyance of water to downstream diversion points. The latter item includes water which must be delivered from one region to another or to an adjoining country as a result of a treaty or interstate compact.

Water needed for in-stream uses must obviously remain in the stream, but it is not consumptively used except for some small evaporation losses from hydroelectric reservoirs and transpiration by riparian vegetation. Thus, in-stream use is a true multiple use of water and the desired minimum streamflow is determined by that use needing the largest flow. If the flow is adequate to satisfy this use, all other uses should find the flow sufficient. The WRC has completed a preliminary examination of in-stream needs as part of the Second National Assessment and has found streamflows for fish and wildlife maintenance are usually the dominant need. They have developed "in-stream flow approximations" which are the percent of average annual streamflow desired for fish and wildlife at the outflow point(s) of each of the 106 WRC subregions as illustrated in Figure 3.4. These estimates will be refined by future work and techniques must also be developed for estimating and displaying in-stream needs at other points in the subregions.

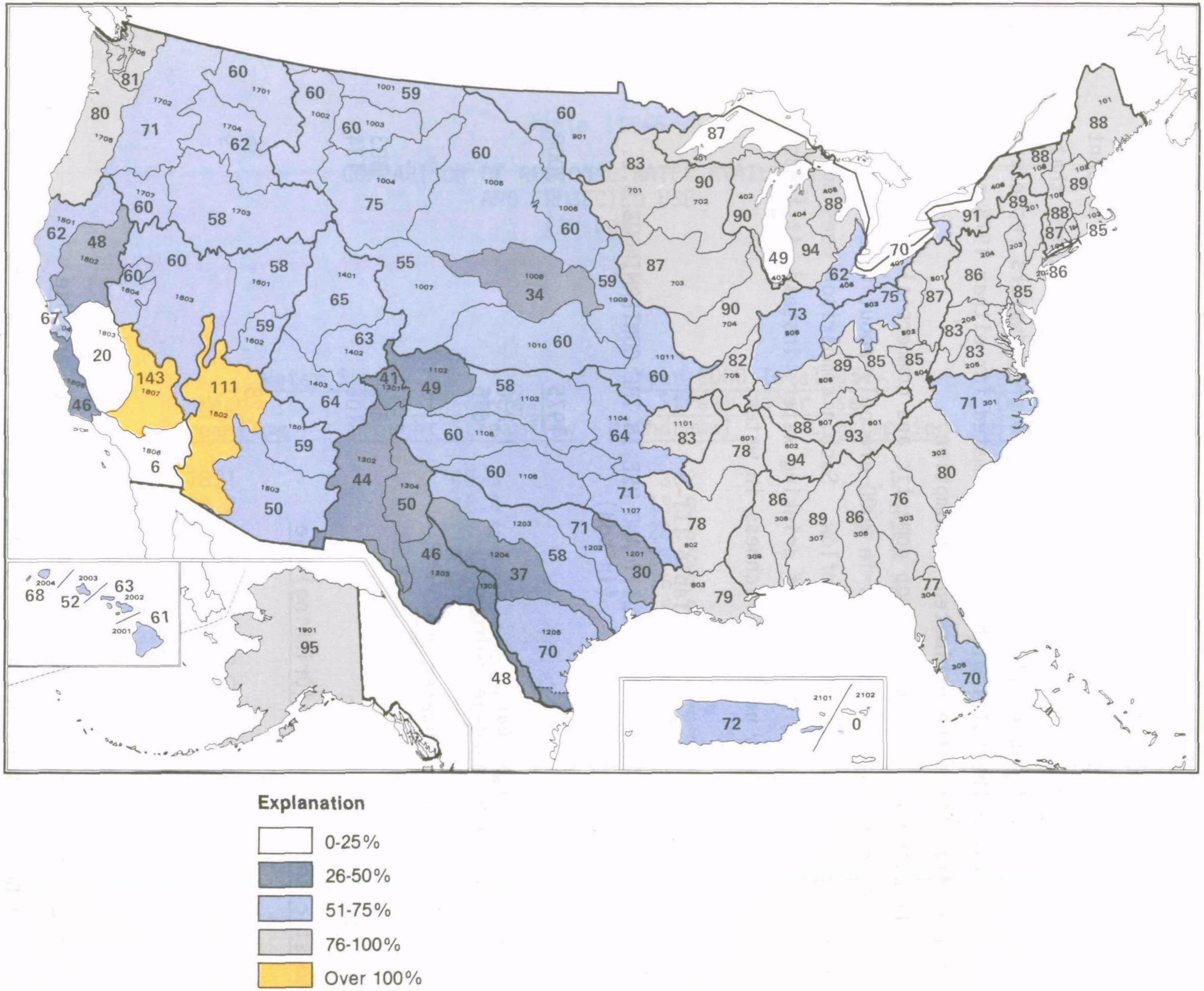


Figure 3.4 IN-STREAM FLOW APPROXIMATIONS FOR FISH AND WILDLIFE, AS A PERCENTAGE OF TOTAL STREAMFLOW

Source: WRC (1978a)

C. Comparison of National Availability and Use

As a first step in assessing the adequacy and dependability of drinking water supplies, the national resource is compared to present and WRC projected use (Table III-5). This comparison indicates that, on a nationwide basis, streamflow and interactive groundwaters represent more than twice the total withdrawals estimated for either 1975 or 2000 and over five times the estimated consumption.

If attention is focused upon domestic and commercial uses, it is seen that anticipated withdrawals in 2000 are only about 5 percent of the once-in-20-year drought streamflow. Such a comparison does not show an imminent nationwide shortage of drinking water; instead, it tends to highlight an apparent national richness in water.

Table III-5

COMPARISON OF WATER AVAILABILITY AND USE IN THE CONTERMINOUS U.S.
(in bgd)

Availability	1975	2000
Streamflow (Average Year)	1,230	
Streamflow (Once-in-20-year-drought)	675	
Total Off-Stream Freshwater Use		
Withdrawal	335	303
Consumption	106	134
Domestic and Commercial (Drinking) Use		
Withdrawal	28	36
Consumption	7	9

Source: WRC (1978a)

D. Regional, Subregional, and Local Availability and Use

The national perspective masks the regional variability in both available supply and expected use; these must be examined to determine whether regional deficiencies exist. Table III-6 compares the mean

Table III-6

COMPARISON OF REGIONAL WATER AVAILABILITY
AND PROJECTED USE
(in bgd)

	Region	Water Supply		Year 2000 Total Off-Stream Water Use		Year 2000 Domestic and Commercial Water Use	
		Mean Streamflow	Once-In-20-Year Drought Streamflow	Withdrawal	Consumption	Withdrawal	Consumption
1.	New England	78.1	48.3	3.2	1.1	1.8	0.3
2.	Mid-Atlantic	79.2	48.4	13.9	3.5	6.0	1.0
3.	South Atlantic-Gulf	228.0	121.8	28.3	10.1	4.3	1.5
4.	Great Lakes	72.7	44.9	25.6	4.7	5.3	0.7
5.	Ohio	178.0	105.0	16.9	4.3	2.9	0.5
6.	Tennessee	40.8	31.4	6.0	1.1	0.5	0.1
7.	Upper Mississippi	121.0	65.3	7.9	2.7	2.4	0.4
8.	Lower Mississippi	433.0	202.0	24.8	5.5	1.0	0.4
9.	Souris-Red-Rainy	6.0	1.8	0.6	0.4	0.1	0.0
10.	Missouri	44.1	17.6	44.4◄	19.9◄	1.5	0.4
11.	Arkansas-White-Red	62.6	21.6	13.3	8.9	1.1	0.4
12.	Texas-Gulf	28.3	6.3	15.0◄	10.5◄	1.9	0.7
13.	Rio Grande	1.2	.2	5.6◄	4.0◄	0.4◄	0.2◄
14.	Upper Colorado	10.0	3.9	7.5◄	3.2	0.1	0.0
15.	Lower Colorado	1.6	1.2	7.9◄	4.7◄	0.8	0.4
16.	Great Basin	2.6	1.2	7.3◄	4.0	0.5	0.2
17.	Pacific Northwest	255.3	179.7	33.8	15.2	1.3	0.3
18.	California	47.4	19.5	41.3◄	29.7◄	4.4	1.8
19.	Alaska	905.0	705.0	0.7	0.5	0.1	0.0
20.	Hawaii	6.7	3.8	1.3	0.7	0.3	0.1
21.	Caribbean	4.9	1.6	0.9	0.3	0.5	0.1

Source: WRC (1978a)

natural supply and the once-in-20-year drought streamflow with projected year 2000 water withdrawals and consumption for the 21 WRC regions. Also listed are projected domestic and commercial withdrawals and consumption.

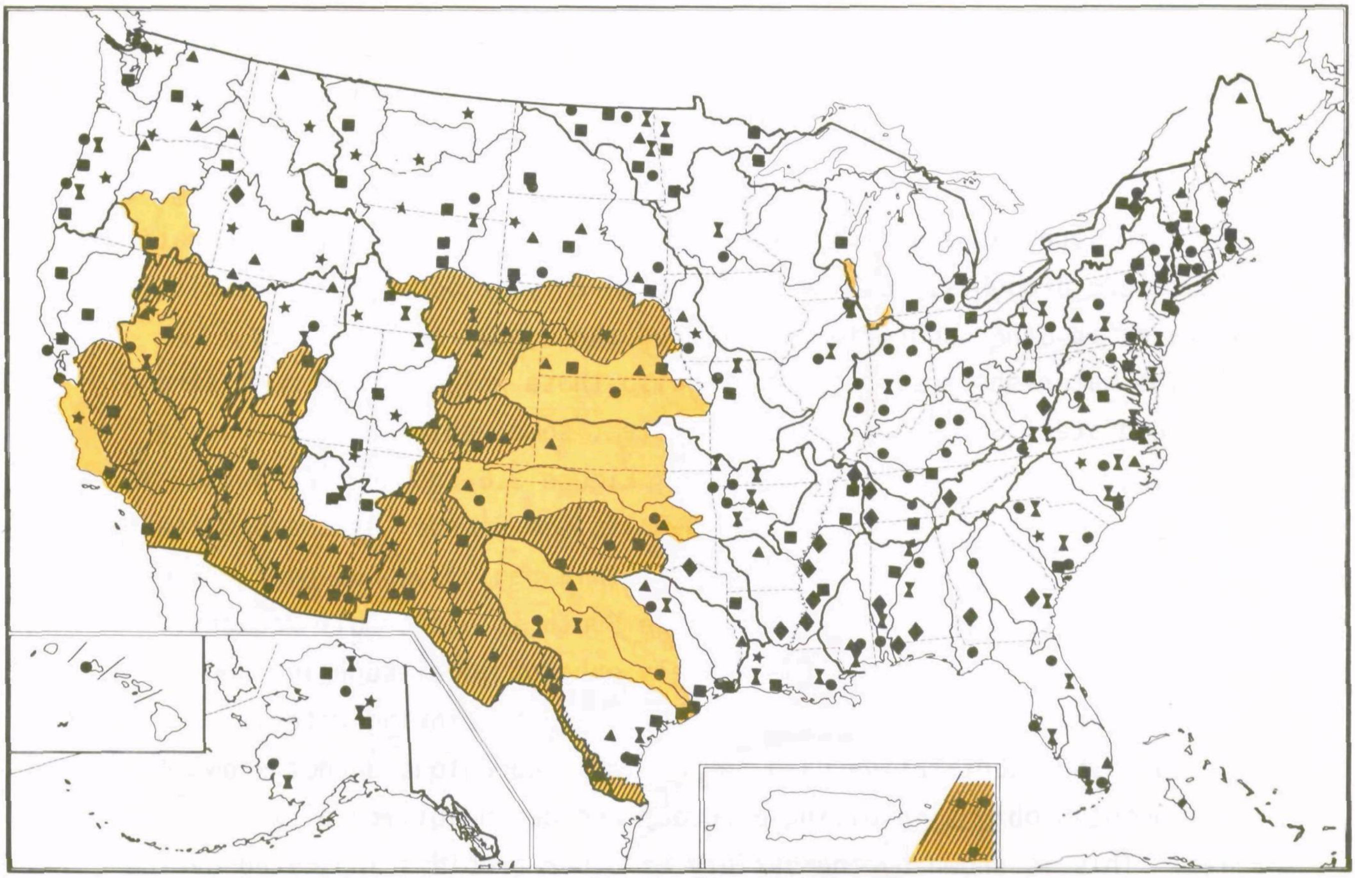
Water supplies are most dependable in the Northwest, Northeast and Southeast because the drought flows are a high percentage, on the order of 50-70 percent, of the mean annual supply. The greatest variations, and least dependable supplies, occur in the semi-arid Southwest and Southcentral regions where drought flows are a small percentage, less than 40 percent of the mean supply. However, even in the humid regions of the country serious drought conditions can result from a series of dry years as evidenced by the 1961-65 drought in the Northeast. Thus, specific consideration of drought conditions and their frequency of occurrence is an important aspect of water availability throughout the country.

In comparing projected withdrawal and consumption with the once-in-20-years streamflow, the arrows in Table III-6 indicate potential limitations of supply in the Missouri, Texas-Gulf, Rio Grande, Upper and Lower Colorado, Great Basin and California regions. It is noted that the Arkansas-White-Red region also experiences shortages, but these are masked by the dryness of the upper basins as compared with the relative wetness of the lower basins. It is apparent that the geographic and temporal variations in water availability combine to make water supply a major concern in the Southwest and Southcentral portions of the country.

In comparing projected regional domestic and commercial water use with the once-in-20-year streamflow as an indication of the adequacy and dependability of drinking water supplies, the Rio Grande Region is the only one which indicates a significant imbalance.

A further regional comparison of mean streamflow with "in-stream flow approximations" for fish and wildlife shows major shortages in the Rio Grande, Lower Colorado and Great Basin regions (WRC, 1978a).

A subregional comparison of available surface supplies and projected use is presented in Figure 3.5. Distinction is made between subregions which may be water-short during an average year and others



Explanation

Subregion with inadequate streamflow ("1975"-2000)

70 percent depleted in average year

70 percent depleted in dry year

Less than 70 percent depleted

Specific problems *(as identified by Federal and State/Regional study teams)*

★ Conflict between offstream and instream uses

Inadequate supply of fresh surface water to support–

Offstream use

● Central (municipal) and noncentral (rural) domestic use

⧗ Industry or energy resource development

▲ Crop irrigation

Instream use

■ Fish and wildlife habitat or outdoor recreation

◆ Hydroelectric generation or navigation

Boundaries

Water resources region

Subregion

Figure 3.5 INADEQUATE SURFACE WATER SUPPLY AND RELATED PROBLEMS

Source: WRC (1978a)

which may have problems during dry years based on the once-in-five-year streamflow level (WRC, 1978c). In general the 26 subregions shown in the Figure as having problems with inadequate streamflow are the ones that have intensive water developments withdrawing a large percentage of available supplies and also making extensive use of water for irrigation. More severe droughts, such as the once-in-20-year occurrence, result in shortages in other subregions scattered throughout the U.S.

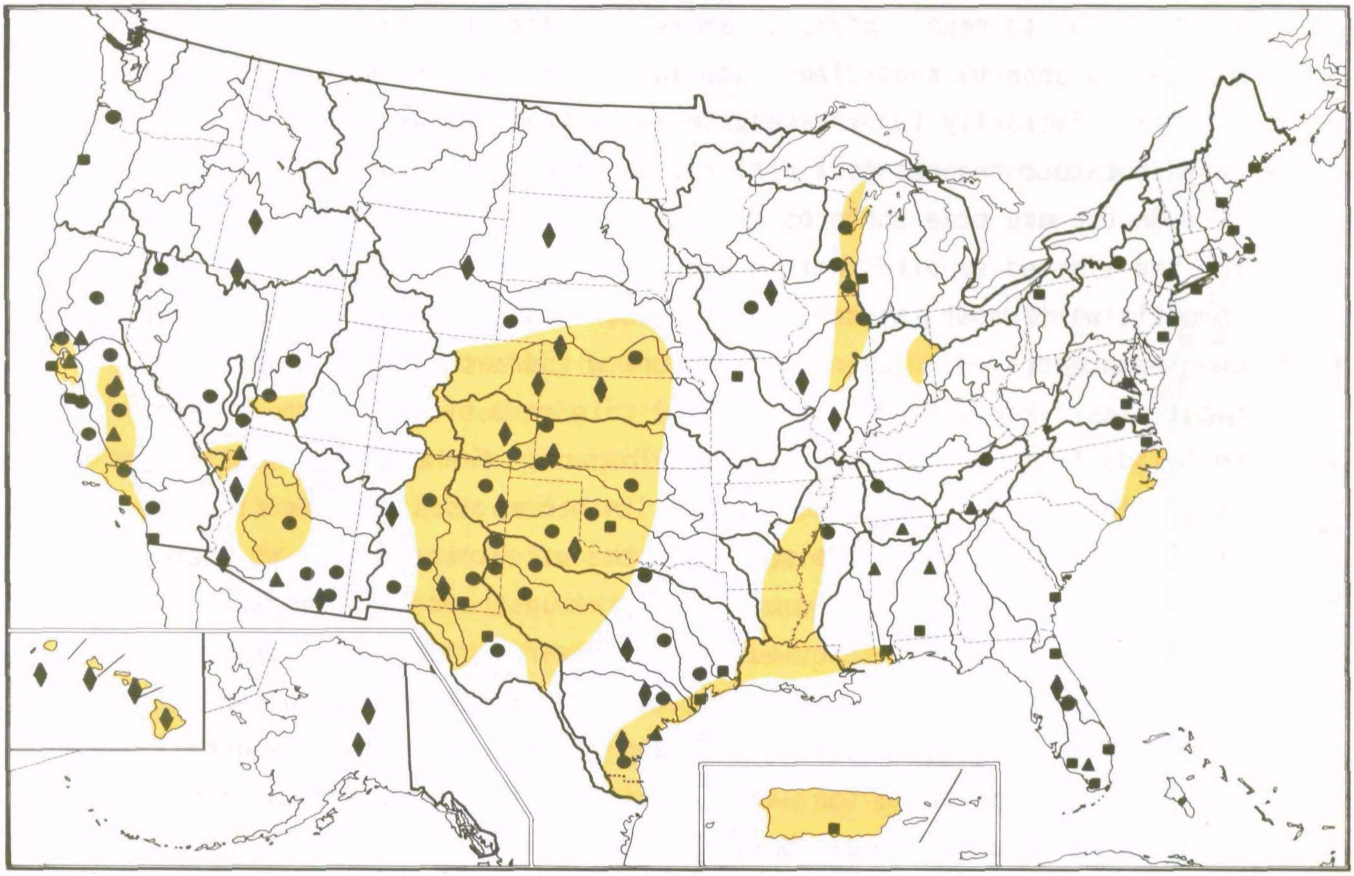
The water-short subregions are also those which depend most strongly on groundwater for supplies and, as noted, some regions are seriously depleting this resource by mining. As Figure 3.6 shows, groundwater depletion is widespread in the Texas-Gulf, Rio Grande, Arkansas-White-Red, Missouri, Lower Colorado and California regions, plus portions of the Upper and Lower Mississippi and the South Atlantic Gulf regions. Continuation of mining could ultimately exhaust local supplies and create severe shortages, including shortages of drinking water.

Even the quantitative data for the WRC subregions do not show the spectrum of problems involving adequacy and dependability of water supplies. This is shown by the variety of other problems indicated by the markings in Figures 3.5 and 3.6.

E. Domestic and Commercial Water Quantity Problems

Problems of national significance regarding water availability occur on a regional, subregional, or local basis as opposed to being of national scope. The national significance is that they sometimes occur in many different localities.

From a supply viewpoint, major regions of the country are using water in excess of their presently sustainable resource. Some areas are entirely dependent on groundwater mining. Other areas, where surface waters are used, have been able to satisfy growing demands by means of the relatively high yields from normal and wet-year streamflows. When droughts occur, however, it is often found that increases in demand have eliminated the drought protection which the system was designed to provide. As a result of these droughts, or when groundwater mining evolves into dwindling of available supplies, severe economic, social,



Explanation

Area problem

Area in which significant ground-water overdraft is occurring

Unshaded area may not be problem-free, but the problem was not considered major

Specific problems ***(as identified by Federal and State/Regional study teams)***

- ● Declining ground-water levels
- ♦ Diminished springflow and streamflow
- ▲ Formation of fissures and subsidence
- ■ Saline-water intrusion into fresh-water aquifers

Boundaries

Water resources region

Subregion

Figure 3.6 GROUND-WATER OVERDRAFT AND RELATED PROBLEMS

WRC (1978a)

and political repercussions are often cited as the basis for national intervention to rescue affected areas. In effect, national taxpayers are called upon to subsidize state and local governments who failed to plan satisfactorily for an adequate and dependable water supply. To avoid such occurrences is a national concern.

On the use side the problem is increasing competition among uses for the limited supplies within various regions and subregions. This competition is most intense in water-short subregions of the Southwest and Southcentral U.S. where agriculture withdraws and consumes large quantities. New water uses intensify this competition; examples are coal liquefication and oil shale development. Perhaps most significant is the increased recognition given to in-stream uses such as fish and wildlife. Competition also occurs in the water-rich Northeast where growing metropolitan areas compete for the upstream supplies which are preferred as drinking water sources. The variety of uses, combined with their tendency to grow in magnitude, makes competition for water a continuing nationwide problem. The WRC (1978a) provides more detail on the overall competition for water and its regional study teams address the problem on a more local basis.

Even in those subregions of the country where general water quantity problems exist or can be expected in the next two decades, it is postulated that domestic and commercial water needs could always be met with only small reductions in other uses. This does not mean, however, that water availability problems do not exist for these uses. Rather, these problems are local problems, hidden in the broader regional picture; but they are no less important because they are local. Typical problems are discussed below as are possible opportunities for solving them.

1. Inadequate Water Supply

Many large urban areas have already exhausted the natural freshwater supply within their environs and have built aqueducts reaching some distance away to augment their supply. Boston, New York, Denver, Phoenix, San Francisco and Los Angeles are examples.

To illustrate the predicament, New York City imports an average of 1421 mgd from the Upper Hudson and Delaware areas. This has caused water quality problems for the exporting regions by allowing salt water to extend farther up the Hudson and Delaware Rivers. It is estimated that without a conservation program the deficit between demand and safe yield in the New York metropolitan area could reach more than 500 mgd in 2000 (WRC, 1978d).

Although Chicago has a large supply source in Lake Michigan, it is limited to 2,068 mgd from this source by a Supreme Court Ruling and the pressure on this limited supply is increasing rapidly, while groundwater use is exceeding the recharge capability of the aquifer (WRC, 1978e).

Many smaller cities and rural water districts face similar problems but lack the resources to construct aqueducts or have no place to go for supplies. Figure 3.5 identifies severe domestic shortages from a local viewpoint in over half of the WRC subregions. These problem identifications are based on the knowledge of the Federal and State/Regional study teams which participated in the WRC's Second Assessment. It is suspected, however, that many small community systems with supply problems were not included on the map. A more detailed reading of regional assessment data indicates the lack of specific information. Even when problems are identified, the precise nature or location is frequently not revealed as the following problem statements exemplify:

- New Hampshire Coastal Area. "...by 1980 water supplies in several area communities, among them Epping and Raymond, will not be sufficient to meet the demands placed upon them" (WRC, 1978f).

- Tennessee Region. "Some smaller communities located near the rim of the basin develop water supply problems during times of drought. Marion, Grundy, Cumberland, and Morgan Counties in Tennessee are four counties where the problem is most pronounced. Except for Crossville, Tennessee, most of the affected communities are under 1,000 in population. Streamflows in these locations are generally intermittent because of the very small drainage areas, and the groundwater is unreliable because of the small recharge areas and type of aquifers" (WRC, 1978g).

- Texas Gulf Region. "A significant portion of the Region's population still resides in rural areas and recent trends indicate that the population of these areas is beginning to increase after decades of decline. Rural water systems generally have difficulty in meeting drinking water standards and in providing a dependable, uninterrupted service, because of their relatively small size and low density of service-area population result in high costs per customer" (WRC, 1978h).

- Ohio Region. "Except for a few localized areas, there appears to be an abundant availability of water resources (ground and surface) to meet the demands of the Basin. The existing problems are usually related to the local distribution system except for a few rural areas where quantity problems exist" (WRC, 1978i).

- Pacific Northwest Region. "Thus, in spite of the large annual supply of water in the Region, water requirements in many areas are not adequately met largely because supplies are not available when and where they are required" (WRC, 1978j).

In addition to persons served by large and small "community" water systems, 10 to 15 percent of the Nation's population is served by individual sources, usually wells. An additional 2 percent has no running water at all. Although some of these people almost certainly experience water shortages, there is no direct indication of their extent.

2. Groundwater

Groundwater is an attractive source of domestic and commercial water. It is usually pure and small supplies are relatively inexpensive. Many small community systems, and some large ones, suffer supply difficulties as regional groundwater levels drop under sustained overdrafts involving larger users such as agriculture. Other cities draw from small local aquifers which could at one time supply adequate water but as population grows the capacity of the source is exceeded. Often supplemental water must be brought long distances. In some instances depletion of streamflow has decreased the recharge to an aquifer below a level sufficient for the water system using the aquifer.

Declining water tables have permitted movement of ocean water into aquifers on the Nation's coasts and withdrawals in some interior aquifers have permitted saline water from an adjacent aquifer to enter a fresh water aquifer. Such penetration may make the source unsuitable for domestic use. This problem is insidious in the sense that penetration occurs slowly over long periods of time and it is difficult to flush the saline water out of the aquifer except over equally long time periods. Continuing irrigation of land overlying an aquifer can cause a slow increase in salinity. Salts in irrigation water are concentrated by evaporation and can be leached back to the underlying groundwater. Domestic supplies drawn from the same aquifer become progressively less desirable and may become unusable. Groundwater of the Welton-Mohawk project near Yuma, Arizona and in the San Joaquin Valley of California are examples of this problem.

As was indicated in Table III-2, groundwater overdraft is occurring in 12 of the 18 WRC regions in the conterminous states. The seriousness of this situation is highlighted by the following examples:

- Nearly 10 million acres or almost 20 percent of the presently irrigated acres overlying the Ogallala aquifer in the High Plains of West Texas and Eastern New Mexico are threatened by depletion of the aquifer. This underlying water supply is expected to be exhausted within 30 to 50 years (WRC, 1978h). Essentially all community water supply systems in the area rely on this source as well and they will also be adversely affected.

- Under present rates of pumping in Southeast Georgia, groundwater quality is threatened in the Savannah area and salt water intrusion is beginning in the Brunswick area. Groundwater withdrawals are expected to double between 1970 and 2000. Some small domestic users of these aquifers do not have access to public water systems and will have to go deeper with their wells to reach uncontaminated sources which will in turn aggravate salt water intrusion into lower aquifers. (WRC, 1978k).

- Users in California are currently withdrawing 2.2 bgd annually which is in excess of recharge. Based on estimates of the amount that can feasibly be withdrawn from groundwater aquifers it appears that they could exhaust groundwater within the next 50 years. The range in de-depletion of 7 to 31 percent in the five out of seven

California subregions indicates that the impact will be felt considerably before that 50 year median number (WRC, 1978c). Indeed, the San Joaquin Valley, with the largest groundwater overdraft of any area in the state has resulted in increased pumping costs, threat of quality degradation in some locations and land subsidence in others (WRC, 1978k). Domestic users will again feel the shortage as well.

3. Drought

Most communities are subject to the risk of drought. Generally speaking it is difficult and costly to provide a system which can cope with all possible droughts. Those communities using groundwater as a source are usually in the most favorable position since the supply does not usually decrease rapidly and can be augmented fairly quickly through construction of a new well. The exception to this generalization is source aquifer depletion by mining but, even in this case, droughts should not interrupt the community's supply until the aquifer is depleted to the point where it is no longer a feasible source.

Communities depending on surface streamflow can always expect a drought period in which available supplies present serious problems. Such an occurrence is more likely to happen in the regions where current use is a substantial fraction of available supply but it can happen in any part of the country. Local problems are sometimes accentuated by failure of the community to keep its system expansion on a par with increasing demand or by its failure to discourage growth if supplies cannot be increased. Such was the case in the water shortage for some Northeastern areas during the early 60's and some Western areas during the mid 70's.

There is an absence of detailed data on community water systems and their hydrologic supply characteristics. Thus a nationwide or even regional assessment of community water supply dependability and problems under drought conditions is not possible at this time. While shortages created by drought are annoying, they do not usually create insurmountable problems for most communities. Emergency supplies and public education leading to reduced use have seen many communities through relatively severe drought without serious consequences.

4. Population Growth

The impact of population growth on available supply is illustrated Hood County, Texas which has been largely a rural agricultural area drawing groundwater to meet its needs. In 1969 the Brazos River Authority completed Lake Granbury which surrounds the County Seat on three sides. With the lake as an attraction Hood County is becoming a bedroom community for Ft. Worth about 40 miles away. The expanding population, with a higher per capita water demand than the rural residents, is rapidly exceeding the available groundwater sources. Although Lake Granbury is close, its water has 1400 mg/l of salt compared to the 500 mg/l standard for drinking water. A new source must be found and developed which will be costly, or a supply must be purchased from some large supplier in the area (Ruesink, 1979).

Many small suburban communities are encountering this problem. They are outgrowing their supply and face high costs to develop new sources.

5. Conservation

Conservation offers an opportunity to extend the utility of limited supplies. It would appear that the timing is ideal for implementation of conservation measures, because of the recent attitudinal change toward environmental awareness and because additional developable supplies are increasingly expensive. More and more frequently conservation is likely to be recognized as one of the most economical means for satisfying water needs associated with increased population or production. Following are examples of savings that might be anticipated from conservation (Metcalf & Eddy, 1976):

- Domestic in-house use might be reduced by between 30 and 50 percent of present average values with the use of pressure-reducing valves, flow-limiting shower heads and dual-cycle toilets. Such changes could be achieved easily in new and remodelled homes.

- Metering of domestic central supplies may reduce outdoor uses at presently unmetered houses by 50 to 80 percent, and will also enable the assessment of losses due to leakage in the distribution system, which may amount to between 30 and 50 percent in some instances.

- Additional conservation measures oriented toward sprinkling should be able to realize a 10 percent reduction in yard use with no significant sacrifice in landscaping.

- Conservation on the part of commercial and industrial users of municipal supplies could achieve a 5 percent reduction simply based on good housekeeping. Adoption of additional measures such as water conserving toilets, changes in production processes and recycling should provide substantial additional water savings.

The benefits of conservation vary. In coastal locations where water supply diverted from mountain streams is used only once and then discarded to the ocean, any savings in withdrawal are important since they make water available for a different use, or perhaps a whole sequence of uses. On the other hand, with inland users, savings in water consumption are more important than water withdrawn since it is only consumed water which is unavailable for downstream uses. An important aspect of any conservation strategy may be to not go too far. For example, normal-year sprinkling use may provide a crucial buffer which allows domestic users to reduce their demands during drought periods enabling reduced municipal supplies to satisfy the vital uses.

Industrial recirculation provides an opportunity to reduce competition for water supplies in some localized settings. To the extent that headwaters or groundwater withdrawals are not developed by industry, they can be made available to other users such as domestic users. Recirculation is now being extensively implemented as a result of water quality regulations. The additional possibility of industrial conservation through process changes which decrease consumption may be helpful in special local situations and should not be overlooked.

Irrigation use is a prime candidate for conservation because of the relatively large quantities of water involved and the possibility for releasing conserved water to other uses such as domestic. However, agricultural practices are very sensitive to cost changes and the increased efficiencies projected by the Second Assessment will require intensive efforts. In general, it may be more important for agriculture to lessen consumptive losses rather than to decrease overall withdrawals.

Agricultural conservation is being addressed in detail by a Task Force working to implement President Carter's Water Policy.

6. Reuse

A second use of water discarded by a first user is defined as reuse. It may occur either indirectly, after water has been discharged to a natural water course, or directly when the first user's effluent is piped directly to the second user. Reuse is distinguished from recirculation, which involves reuse of effluent by the first user, and from conservation which involves a decrease in either gross water use or consumption. A recent draft assessment of reuse potential indicated that about 173 bgd of wastewater is presently available for reuse and that the total of present uses which could accept wastewater as a supply is 331 bgd (Culp/Wesner/Culp, 1978). However less than one bgd is presently being directly reused. These figures do not account for indirect reuse -- i.e., where water withdrawn from the stream has been used before -- which can account for as much as one gallon out of five withdrawn for municipal water supply (National Water Commission, 1973).

It appears that present technology is sufficient to allow considerable expansion of wastewater reuse for nonpotable purposes with the cost of alternative sources being a major determining factor. Many reuse processes will increase consumption, a factor which needs to be considered in specific cases. However, environmental considerations to reduce or eliminate pollutant discharges are factors to be considered in promoting reuse. The health concerns regarding wastewater reuse for potable purposes (e.g., virus, asbestos, new toxic chemicals) require additional research before direct reuse for drinking water supplies can be considered safe.

7. Water Consumptive Waste Management Technologies

Management of wastewater by land treatment and disposal methods or by evaporation lagoons, or its reuse for irrigation are reasonably attractive and economical in some parts of the country. However, care must be taken in some states since such techniques may interfere with downstream water rights. If such prior rights exist, diversion of the wastewater to land treatment or other consumptive use must usually be preceded by negotiation for or purchase of water rights. These costs can significantly impact the economics involved in the wastewater management decision. Land treatment now constitutes less than 2 percent of national municipal wastewater treatment capacity and is projected under present conditions, to grow to about 5 percent by 1990 (Metcalf and Eddy, 1978). Thus, even in 1990, and assuming 50 percent consumption, it would constitute only about 0.5 percent of projected national water consumption. Although this is not a magnitude that warrants recognition as a national water quantity problem, the situation emphasizes the importance of allowing local communities to decide on systems most suited for their situation and needs rather than an effort to urge implementation of a standard technique throughout the country.

F. Summary/Findings

The preceding assessment of water availability and use, as related to domestic and commercial supplies and wastewater coordination, is summarized in two sets of findings -- those peripherally related to community activities involving other major uses, and those which primarily involve community water supply or wastewater management.

With regard to those primarily involving other uses:

- Although the Nation as a whole is water rich, competition for water is intense in many locations and this intensity is increasing. Competition is most intense in water-short subregions of the Southwest and South-central U.S. where agriculture withdraws and consumes large quantities. New water uses such as coal liquefaction and oil shale development will intensify this competition. Competition also occurs in the water-rich Northeast where metropolitan areas compete for upstream supplies.

- Groundwater mining and resultant depletion poses a major threat to all water users. Overdraft is occurring in 12 of the 18 regions, and 59 of the 99 subregions, in the conterminous states, while groundwater depletion is widespread in the Texas Gulf, Rio Grande, Arkansas-White-Red, Missouri, Lower Colorado, and California regions, plus portions of the Upper and lower Mississippi and the South Atlantic Gulf regions. As noted in Chapter II, this is primarily due to the lack of institutional and legal mechanisms to control additional development of the resource, even when its substainable yield has been substantially exceeded.

- Agricultural water use is not only a major factor in the intense competition for water but also in groundwater mining. This use is a prime candidate for potential savings through conservation and increased efficiency of production. As noted, such changes in agricultural use have been projected by WRC's Second Assessment (1978a).

- In-stream uses of water are important and are complicated by the large quantities involved, by their relatively recent recognition due to adverse impacts from total diversion of streamflows for off-stream uses in some localities, and by their uncertain legal status. Major shortages for in-stream use occur in the Rio Grand, Lower Colorado and Great Basin regions (WRC, 1978a).

- Water consumptive technology (cooling ponds and towers) in steam electric and manufacturing sectors is not as important in determining future water consumption as are the projected per capita increases in consumption of electricity and manufactured goods.

The above issues are all of national concern and are being addressed in several forums, including:

- The WRC Second Assessment (1978a).

- The implementation task forces for President Carter's Water Policy (Martin, 1979).

- The EPA report on water allocation/water quality coordination in response to Section 102d of the Clean Water Act (EPA, 1979).

- The Office of Technology Assessment's 1979 priority list which assigns the "Impact of Technology on National Water Supply and Demand" top priority (U.S. Congress, OTA, 1979).

The second group of findings focus on domestic and commercial water supplies and wastewater treatment. They include:

- Aquifer depletion by groundwater overdraft/mining may have extreme adverse impacts on community and domestic rural water supplies. Further information on these potential impacts is needed.

- Although all types of communities may encounter problems in obtaining adequate quantities of supply, the problems appear to be most severe in small communities which must rely on closer sources and tend to experience more rapid growth and more volatile demands. In particular, the WRC's Second Assessment (1978a) points toward a disturbing number of local shortages (i.e. in over half of the subregions) on a widespread basis. These potential shortages need to be more specifically characterized.

- Municipal conservation appears to offer significant potential for alleviating water demand and water competition problems in localized areas, particularly in growing communities. However, information which adequately quantifies this potential, and identifies advantages and disadvantages, is not readily available.

- Reuse of municipal effluents appears to offer additional potential to ease the competition for water through application to such nonpotable uses as agricultural and landscape irrigation, groundwater recharge, and industrial uses. However, the economics of reuse are presently uncertain.

- The dependability of community water supplies in the face of droughts cannot be assessed on a national or regional basis using available information.

- Although water consumptive community wastewater treatment technologies do not pose problems of national significance, they do point to the need for flexibility of national programs so that local situations can be adequately considered.

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Chapter IV

PROTECTION AND ENHANCEMENT OF WATER QUALITY

A. Key Legislation and Programs

1. Federal Legislation

The decade of the 70's saw considerable activity in the field of water quality management. A sizeable body of legislation has been created for protection or improvement of the quality of water in the U.S., including in-stream quality and the quality of drinking water. Key legislation is discussed below.

a. Safe Drinking Water Act (1974/77)

The Safe Drinking Water Act delegates regulation of the quality of drinking water supplies to EPA and the states. The major provisions of the Act and associated administrative actions to control drinking water quality include:

- National interim primary drinking water regulations to protect public health.
- Proposed primary regulations for organic chemicals.
- Requirements for notification of consumers and states if water supply systems are not in compliance with a pertinent regulation.
- Emergency powers for the Administrator to act to protect the public health.
- Review of state implementation programs allowing states primary enforcement responsibility.
- Regulations for state underground injection control programs.
- Regulations for designation of sole source aquifers.
- Research and demonstration projects including: carcinogens, current standards, costs, waste disposal

practices and effects on groundwater, fertilizer and pesticide impact on groundwater, availability of present and future supplies, and rural water supplies.

- Establishment of and consultation with the National Drinking Water Advisory Council.

b. Federal Water Pollution Control Act/Clean Water Act (1972/77)

These two acts are the primary legislation covering point and nonpoint discharges to surface water. The major provisions of the acts relating to water quality protection are:

- Definition of desired water quality in terms of "water quality standards".

- Issuance of National Pollutant Discharge Elimination System (NPDES) permits to assure compliance with water quality standards and effluent limitations. Specifically: a permit is required for all point source discharges to surface water; industrial dischargers must use best practicable control technology (BPT) for all pollutants by July, 1977 -- a deadline which may be extended under certain circumstances; industrial dischargers must use best conventional control technology (BCT) for conventional pollutants defined as biochemical and chemical oxygen demand, total suspended solids, total phosphorus, oil and grease; for other pollutants best available technology economically achievable must be used by July 1, 1984; publicly-owned treatment works (POTWs) must use secondary treatment by July, 1977, 1977 or July 1, 1983 for best practicable wastewater treatment technology (BPWTT).

- Effluent guidelines for major industries set allowable loading in lbs per day.

- New Source Performance Standards for 27 industries.

- Maximum permissible concentrations for 129 toxicants.

- Pretreatment of industrial waste before discharge to municipal treatment systems.

- Requirement for states to develop implementation schedules for effluent limitations and in-stream water quality standards, prepare an inventory of existing POTWs and ranking of need for any new waste treatment works.

- Areawide Wastewater Management Planning (Section 208.)
- Basin planning (Section 209).
- Clean Lakes Program.
- Guidelines for control of nonpoint source pollution.
- Grants to states for construction of wastewater treatment facilities.
- Research and development programs on control of surface mining pollution, disposal of waste oil, technology to reduce water consumption and thus sewage flows, rural sewage systems.
- Studies on estuaries, control of thermal discharges, water quality inventory, water supply and wastewater coordination.
- Water Pollution Control Advisory Board.

Some point source dischargers have been unable to meet the 1977 goals because of delay in funding of construction grants for POTWs, disputes over the proposed effluent guidelines, and delay in formulating the guidelines and treatment standards. Effluent guidelines and New Source Performance Standards have been set for most industries. Regulations covering pretreatment of industrial waste were promulgated in June, 1978, although the specific maximum concentrations of toxicants have not been completed. The 208 plans for most areas are currently being reviewed by the states and EPA.

c. Other Acts

The Toxic Substances Control Act (1976) regulates the testing, manufacture and distribution of toxic chemicals. The specific requirements are to be outlined in additional regulations which have not been completed.

The Resource Conservation and Recovery Act (1976) seeks to promote reuse and recycling and to regulate hazardous and solid waste disposal. A major concern is to minimize the impact of landfill or dump leachate on groundwater aquifers. Under this act an inventory of open dumps will be made; the goal is to close or upgrade these dumps by 1983. Guidelines for establishing sanitary landfill sites and types of waste that should be disposed in them were developed in February, 1978.

Under the Clean Air Act (1977) EPA set air quality standards, new source performance standards for new plants, and emission limits for existing stationary sources. Sludges, a by-product of most air quality control technology, must be disposed of so as to avoid pollution of drinking water supplies.

The National Environmental Policy Act (1969) requires that before commencing construction or operation, all Federal agencies prepare an Environmental Impact Statement for all major Federal or Federally funded projects significantly affecting the human environment. The impact of the project on nearby drinking water supplies would be assessed and, if necessary, mitigating measures identified.

The Surface Mining Control and Reclamation Act (1977) authorizes the Office of Surface Mining to regulate surface mines based on final regulations published in December, 1978. This Act is intended to reduce pollution from new and existing mines and also sets up an abandoned mine reclamation fund for use in abating pollution from abandoned mines.

2. Federal Programs

A number of Federal programs have been initiated in response to the Federal Water Pollution Control Act/Clean Water Act and the Safe Drinking Water Act. These are discussed below.

a. Federal Water Pollution Control Act/Clean Water Act Programs

NPDES Program. As previously noted, effluent limitations are imposed on dischargers primarily through the NPDES permit program authorized under Section 402 of PL 92-500. Permits generally consist of limitations on volume and concentration of pollutants and schedules of compliance, although they may also specify operating procedures. They are usually imposed for five-year periods. Authority for administering the permit program can be transferred from EPA to the states, and 32 states now administer the program. EPA retains the authority to review individual permits issued by states for consistency with the Act.

404 Permit Program. The Clean Water Act includes other permit programs besides NPDES, the most important of which is the Section 404 permit program for discharges of dredged or fill material. Activities regulated by this program include the construction of dams, diversions and impoundments, the filling of wetlands, and the disposal of dredged spoil. The 404 permit program is presently administered by the Corps of Engineers, although the 1977 amendments to PL 92-500 authorize transfer of this responsibility to the states. Permit applications are evaluated for compliance with environmental guidelines developed by EPA, in conjunction with the Corps, under Section 404(b)(1).

Construction Grants Program. Section 201 of the Clean Water Act authorizes Federal grants for planning, building and improving publicly-owned sewage treatment works and sewers. Federal financial assistance is available for three steps: (1) planning the facilities, (2) design specifications, (3) actual construction. The program is jointly administered by EPA and the states; EPA is authorized to delegate many of its responsibilities for administering the program to the states.

As indicated earlier, POTWs must achieve secondary treatment standards, or more stringent treatment related to water quality standards, by July 1, 1977, and BPWTT by July 1, 1983. More stringent requirements based on state authority may also be imposed under Section 510 of the Act. EPA defines secondary treatment as numerical values for BOD, suspended solids, and acidity. BPWTT involves an analysis of alternatives, including land application and water reuse, as well as a minimum requirement for secondary treatment. The evaluation of alternatives takes place in the process of facilities planning. EPA's actions in funding construction based on these plans are subject to environmental review under NEPA.

Water Quality Management Planning. The Clean Water Act establishes a variety of planning programs. Section 303(e) provides for the

State Continuing Planning Process, which includes implementation of water quality standards. Section 208 establishes areawide waste treatment management planning, which provides for control of all sources of pollution, point and nonpoint, to the extent practicable. 208 plans are developed either by areawide agencies designated by the state, or by the State itself in areas which have not been designated. Section 106 provides for grants to the states for carrying out various programs under the Act. EPA has developed regulations consolidating programs responding to Sections 303(e), 208 and 106. Section 209 provides for the development of Level B Studies for all basins in the United States under the Water Resources Planning Act.

Nonpoint Source Programs. Section 208 provides for States and local governments to establish programs to control nonpoint sources of pollution. Nonpoint sources can include runoff from activities such as agriculture, forestry, mining, construction, saltwater intrusion, urban stormwater, and residual wastes. States may assume the responsibility for planning for nonpoint sources from areawide agencies.

b. Safe Drinking Water Programs

Underground Injection Control Program. The Underground Injection Control (UIC) Programs of the states are intended to protect potential drinking water supplies from contamination by injection wells. The definition in the act is broad and includes industrial and municipal waste disposal wells, storage, mining and geothermal wells, and wells used for barriers, subsidence control, and recharge. The proposed regulations state that all aquifers with "total dissolved solids" (TDS) concentrations below 10,000 mg/l, and those presently used as drinking water supplies are to be protected unless prior use, contamination, or impractical development precludes its use as a drinking water supply. The primary mechanisms for control are proposed regulations covering well construction and operation, a permit system for deep injection wells (Class I), and rules covering requirements for other classes of wells.

Sole Source Aquifer Program. The Sole Source Aquifer designation is a measure designed to protect large regional aquifers. New proposed guidelines for designation include:

- Source providing more than 50 percent of public water supply.
- Contamination could result in significant hazard to public health.
- Alternative, acceptable water supply sources are not available.

If an aquifer is declared a sole-source aquifer, then an EIS Impact Statement on groundwater effects following NEPA guidelines must be prepared for all federally-funded projects. Four areas have been declared sole-source aquifers: The Edwards Plateau in Texas, the Rathdrum Valley aquifer in Spokane, Washington, the northern island of Guam, and Nassau and Suffolk Counties on Long Island, New York.

Areas currently under study include: Biscayne, Florida; Cape Cod, Massachusetts; Tenmile Creek, Maryland; Twin Cities and the karst region of Minnesota; and Fresno and Scott's Valley in California.

B. Water Quality Standards

1. Drinking Water Regulations and Standards

The interim primary drinking water regulations, including specific maximum contaminant levels (standards), are based on human health considerations and apply to all public systems -- i.e., those serving at least 25 people or having at least 15 service connections and which are utilized at least 60 days per year. These standards, covering ten inorganic chemicals, chlorinated hydrocarbons, bacteria, and radionuclides are presented in Table IV-1.

The proposed secondary standards address the aesthetic and pragmatic factors involving drinking water rather than public health. They include factors which affect taste, odor and the corrosion properties of the water (see Table IV-2). These standards are not Federally enforceable but are considered guidelines which the states are expected to use.

Table IV-1

PRIMARY DRINKING WATER QUALITY STANDARDS

Parameters	Annual Average Maximum Daily Air Temperature °F	°C	Maximum Level+
Inorganic Chemicals			
Arsenic			0.05
Barium			1.
Cadmium			0.010
Chromium			0.05
Lead			0.05
Mercury			0.002
Nitrate (as N)			10.
Selenium			0.01
Silver			0.05
Fluoride			
	53.7 and below	12.0 and below	2.4
	53.8 to 58.3	12.1 to 14.6	2.2
	58.4 to 63.8	14.7 to 17.6	2.0
	63.9 to 70.6	17.7 to 21.4	1.8
	70.7 to 79.2	21.5 to 26.2	1.6
	79.3 to 90.5	26.3 to 32.5	1.4
Chlorinated Hydrocarbons			
Endrin (1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo-5, 8-dimethano naphthalene)			0.0002
Lindane (1, 2, 3, 4, 5, 6-hexachlorocyclohexane, gamma isomer)			0.004
Methoxychlor (1, 1, 1-Trichloroethane) 2, 2-bis (p-methoxyphenyl)			0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67-69 percent chlorine)			0.005
Chlorophenoxys: 2,4-D, (2, 4-Dichlorophenoxyacetic acid)			0.1
Chlorophenoxys: 2, 4, 5-TP Silvex (2, 4, 5-Trichlorophenoxy-propionic acid)			0.01

Parameters	Maximum Level+
Turbidity (for surface water sources)	1 TU up to 5 TU*
Coliform Bacteria	
Membrane filter technique:	1/100 ml mean/month 4/100 ml in one sample if <20 samples/month 4/100 ml in more than 5% if >20 samples/month
Fermentation tube with 10 ml portions:	no coliforms in >10% of portions/month no coliforms in >3 portions/sample if <20 samples/month no coliforms in >3 portions of 5% of samples if >20 samples/month
Fermentation tube with 100 ml portions:	no coliform bacteria in >60% of portions/month no coliform in 5 portions in one sample if <5 samples/month no coliform in 5 portions in 20% of samples if >5 samples/month

Radioactive Material	Level
Combined radium 226 and radium 228	5 pCi/l
Gross alpha particle activity**	15 pCi/l
Beta particle and photon radioactivity from man-made radionuclides	4 millirem/year
Tritium for total body	20,000 pCi/l
Strontium-90 in bone marrow	8 pCi/l

+mg/l unless otherwise stated.

*Includes Ra^{226} excludes Radon, Uranium.

**If meet special requirements.

Source: EPA (1977a)

Table IV-2

PROPOSED SECONDARY DRINKING WATER QUALITY STANDARDS

Parameter	Maximum Level
Chloride	250 mg/l
Color	15 c.u.
Copper	1 mg/l
MBAS*	0.5 mg/l
H_2S	0.05 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Odor	Threshold Order Number 3
pH	6.5 - 8.5
Sulphate	250 mg/l
Total Dissolved Solids	500 mg/l
Zinc	5 mg/l
Corrosion	Non-Corrosive

*Methylene blue active substances.

Source: EPA (1977b)

Specific monitoring requirements including frequency and analytical techniques were mandated in the primary regulations with some discretion allowed the states. Actual monitoring is a local responsibility; analyses must be performed by an EPA or state approved laboratory. The monitoring is more frequent for systems using surface water sources than those using groundwater sources. There are also differences in monitoring depending on the population served by the system and whether it is a community (public system with year-round use) or noncommunity water supply system. If monitoring shows a violation of a primary standard which is confirmed by additional sampling, both the state and the public must be notified. If a significant health hazard exists, emergency provisions for supply would be made.

Organic Chemicals. New standards for organic chemicals were proposed on February 9, 1978 covering trihalomethanes and synthetic organic chemicals. Trihalomethanes (THM), principally chloroform, were isolated from community water supplies in the U.S. in 1974. It has been established that the major source of precursors which react with chlorine during water treatment (disinfection) are the naturally occurring humates in surface waters (i.e., nonpoint source input of decayed vegetation and aquatic material) which react with chlorine to produce haloforms in μg/l concentrations. Other organic compounds in raw water sources are from municipal and industrial point source discharges and from urban and rural nonpoint sources.

Organics which have been identified in drinking water in very small quantities are toxicants, carcinogens, mutagens and teratogens as indicated by animal bioassay tests conducted at high doses. The full effect on humans of long-term ingestion of very low levels of organic chemicals in drinking water is not known. Researchers, workshops, and symposia have been studying the health effects of chlorination and other alternatives for disinfection. Candidates are ozone or chlorine dioxide although no final conclusions have been made.

The concern over THM's in drinking water supplies relates to their carcinogenicity as identified by the National Institute of Health. One proposed organic regulation is a maximum contaminant level of 0.10 mg/l for THM. This standard was set for total THM, not just chloroform, since other halogens can combine with organics. Communities over 75,000 people, or 52 percent of the population served by community systems, would be required to monitor for THM's within three months and comply with the proposed standard within 18 months. Communities with 10,000 to 75,000 people would begin monitoring within six months. Of the 390 systems serving over 75,000 people, 86 systems are estimated to exceed the THM standard. A second regulation proposes the required use of granular activiated carbon (GAC) for all systems serving over 75,000 people in areas of significant contamination by synthetic organic chemicals. The EPA estimates that 61 systems will need to install GAC treatment in response to the two regulations (U.S. EPA, 1978 a, b).

The position of the American Water Works Association (AWWA) on the proposed regulations for organics in drinking water is that the EPA should set a maximum contaminant level (MCL) of 0.3 mg/l for chloroform, the primary THM formed after disinfection, not all THMs. Also, the AWWA proposes that the EPA establish MCLs for 23 organic contaminants in drinking water rather than require treatment with GAC. The AWWA feels that the expense of GAC is not warranted given the uncertainties in determining the hazards of low level exposure, high cost of treatment, and possible side-effects of the treatment itself such as desorption and GAC introduction of substances due to the regeneration process.

2. <u>In-Stream Water Quality Standards</u>

Federal standards for in-stream water quality have been derived based on Class A for water contact recreation and Class B for protection of fish, wildlife and other aquatic life, and are used in evaluating NPDES permits and applications. The Federal standards shown in Table IV-3 are minimum levels, and states may set higher standards and include more use categories.

These standards and criteria have been derived primarily through bioassays on fish, with consideration of human health on the standards for coliforms based on exposure by swimming. Where states have developed other use classes they may have set more stringent standards appropriate to that use.

Table IV-3

IN-STREAM WATER QUALITY MINIMUM STANDARDS

General Criteria

Free from sludge deposits

No floating materials from municipal or industrial discharges

No color or odor from municipal or industrial discharges

No toxic concentrations of substances from municipal or industrial discharges

No visible films of oil or grease

No settleable solids from waste discharges

Specific Criteria	Class A	Class B
Total coliforms	--	$\leq$ 100,000/100 ml
Fecal coliforms	$\leq$ 200/100 ml	$\leq$ 200/100 ml
Dissolved oxygen	$\geq$ 5 mg/l	$\geq$ Trout $\geq$ 6 mg/l $\geq$ 5 mg/l
Temperature	$\leq$ 90°F	Trout-68°F, or 5° rise Other streams-90°F, 5° rise for stream, 3° rise for impoundments
pH	6,5-8,3	6-9
Color	--	Cold-10 JU Warm-50 JU
Turbidity	$\geq$ Secchi disc-1m	$\geq$ Secchi disc-1m
TDS	$\leq$ 500 mg/l or 1/3 more than natural conditions	1/3 more than natural conditions
Gross beta particle activity		$\leq$ 1000pCi/l
Radium-226		$\leq$ 3pCi/l
Strontium-90		$\leq$ 10pCi/l

Source: National Technical Advisory Committee on Water Quality Criteria (1968)

The in-stream standards bear no specific relationship to drinking water standards since the parameters (e.g. dissolved oxygen and temperature) are designed to protect fish and wildlife. Water which meets the in-stream standards is in no sense safe for drinking; for example, it may contain high concentrations of metals. This is not to suggest that more stringent in-stream standards are needed in the interests of safe drinking water. Even if all point source discharges were treated to drinking water standards, natural and nonpoint source pollution reaching the stream would require treatment of the water before domestic use. However, to the extent in-stream standards keep toxic material and oils and greases from the water, treatment for drinking water is made easier and more reliable since some toxic materials might not even be detected at the intake of the water supply system.

C. Treatment Technology

1. Water Supply

Conventional water treatment technologies commonly use mechanical methods such as sedimentation and filtration to remove suspended material from the water, and chemical disinfection -- most commonly with chlorine -- to control bacteria and viruses. Chemical processes may be added such as coagulation to enhance the effectiveness of sedimentation, and chemical softening to remove dissolved salts responsible for hardness. These processes may also be effective against some heavy metals and radionuclides. (AWWA, 1971; Culp and Culp, 1974; Sorg, July 1978; Volhert and Assc., 1974).

Other nonconventional processes have been used to remove various inorganic constituents regulated by the primary standards including ion exchange for nitrate and fluoride removal (Sorg, Feb. 1978) and reverse osmosis, which is effective in significantly reducing the levels of most dissolved solids (Sorg, July, 1978; Feb. 1978). The nonconventional treatment processes are relatively expensive and have not been used extensively. It is frequently more cost effective to develop an alternative source of water supply than to remove inorganic constitutents which exceed the standards. Table IV-4 summarizes data on percent of systems by population size using various standard treatments. More

Table IV-4

PERCENT OF SYSTEMS USING VARIOUS STANDARD TREATMENTS--1975

	Population Category									
Treatment	25-99	100-499	500-999	1,000-2,499	2,500-4,999	5,000-9,999	10,000-99,999	100,000-999,999	>1 Million	Average for All Systems
Disinfection	30	40	56	61	79	71	79	92	100	60
Coagulation	.7	1	8	10	21	20	32	62	100	20
Sedimentation	1	4	8	11	27	20	33	62	91	22
Filtration	6	9	18	20	31	34	39	69	82	28
Pre Chlorination	1	4	6	13	19	39	32	62	73	22
Fluoride Adjustment	.7	2	19	13	24	27	33	54	73	20
Corrosion Control	2	3	12	13	29	41	36	68	91	25
Taste and Odor	0	1	6	4	6	12	18	44	55	13
Aeration	2	2	15	11	15	17	14	25	9	11
Lime Soda	3	2	6	8	10	7	18	22	18	9
Iron Removal	4	6	15	10	16	22	15	20	9	13
Ammoniation	0	.8	0	.9	0	2	4	20	27	5
Activated Alumina	.7	.4	2	4	3	2	5	9	0	3
Ion Exchange	0	1	2	4	5	7	6	3	0	3
Other	2	2	1	.8	2	2	2	5	18	3

Source: Temple, Barker, Sloan, 1977.

recent data are currently being reported by states and stored in the Federal Reporting Data System. This information, when available, will present a more accurate and complete picture of the types of treatment used throughout the country. Table IV-5 shows the effectiveness of various treatment methods in removing bacteria, viruses, and turbidity. Table IV-6 presents information on the relative effectiveness of conventional and nonconventional treatment methods for removing inorganic contaminants, while Table IV-7 shows percent of organics removed by water treatment processes.

2. Municipal Wastewater Treatment

Conventional methods of wastewater treatment employ mechanical operations and biological processes. Screening and sedimentation are used to remove suspended and floating solids. Biological treatment is then used to reduce oxygen demand by microbial consumption and oxidation of some of the organics in the waste. Many different systems are available to accomplish the microbial action and oxidation including trickling filters, activated sludge, and stabilization ponds or lagoons. Chlorination may also be used to reduce the bacterial and viral count, and to a limited extent to provide further oxidation.

When these processes are not adequate to meet in-stream standards a variety of advanced processes are available, although usually at a considerable increase in both first and operating costs. Advanced processes include filtration, nitrification, denitrification, chemical precipitation, stripping, ion exchange, and carbon adsorption. These unit processes can be added to or combined with a secondary treatment plant in any combination to form an advanced treatment system. The individual processes are quite selective in their removals, but the combined advanced system can remove many constitutents. For example, biological denitrification removes nitrate-nitrogen but has little effect on other constituents. An advanced system of chemical precipitation, nitrification, denitrification, and filtration can remove BOD, suspended solids, nitrogen, and phosphorus down to very low levels.

Advanced systems have been used to provide water for reuse in several dual water systems including Irvine Ranch Water District, California,

Table IV-5

EFFECTIVENESS OF TREATMENT METHODS IN REMOVING
BACTERIA, VIRUSES AND TURBIDITY (APPROXIMATE PERCENT REMOVAL)

Process	Bacteria	Viruses	Turbidity
Plain Sedimentation	0-90	-	50-95
Coagulation	significant amounts	90-99	80-99
Rapid Sand Filtration	0-99	0-99	80-99
Slow Sand Filtration	85-99	-	80-99
Diatomite Filtration	85-90	up to 98	80-99
Microscreening	50-80	-	50-80
Chlorination	99	99	-
Ozonation	99	99	-
Reverse Osmosis	99	99	-
Chlorine Dioxide	99	-	-
Activated Carbon	-	up to 90	-

Source: National Academy of Sciences,(1977)

Table IV-6

EFFECTIVENESS OF TREATMENT METHODS FOR REMOVING INORGANIC CONTAMINANTS (APPROXIMATE PERCENT REMOVAL)

Contaminant	Ferric Sulfate Coagulation	Alum Coagulation	Lime Softening	Excess Lime Softening	Activated Alumina Adsorption
Arsenic	90-99 (pH 6-8)	90 (pH 6-7)	60-90	95	99
Barium	-		88-95 (pH 10-11)	90	
Cadmium (soluble forms)					
Cadmium (insoluble forms)	90 (pH>8)		98	98	
Chromium (soluble forms)	-				
Chromium (+3) (insoluble forms)	98 (pH 6-9)	90-98 (pH 7-9)	70-98	98	
Chromium (+6) (insoluble forms)	98-99 (pH 7-9)				
Fluoride		90		30-70	95
Lead (soluble forms)	-				
Lead (insoluble forms)	95-97 (pH 6-9)	80-97 (pH 6-9)	98	98	
Mercury (inorganic forms)	66-97 (pH 7-8)		60-80 (pH 10-11)		
Mercury (organic forms)	85				
Nitrate	-				
Selenium (+4)	85-90 (pH 6-7)				
Selenium (+6)					
Silver	70-90 (pH 7-9)	70-90 (pH 6-8)	70-90	70-90	
Radium	-		80-90 (pH>10)		
Beta and photon emitters				87-96	
Copper					
Iron		90-99 (pH 9.4)			
Manganese	-	90-99 (pH 9.4)			
Sulfate					
Total dissolved solids	-				
Zinc					
Color	95 (pH 4-6)	95 (pH 4-6)			

Table IV-6 (Continued)

Contaminant	Granular Activated Carbon	Ion Exchange	Electro-dialysis	Reverse Osmosis	Diatomite Filtration	Aeration
Arsenic		55-99	80	90-97		
Barium		95	80	90-97		
Cadmium (soluble forms)		95-99	80	90-98		-
Cadmium (insoluble forms)				90-97		-
Chromium (soluble forms)		95	80			
Chromium (+3) Iinsoluble forms)						
Chromium (+6) (insoluble forms)						-
Fluoride		95	80	90-97		
Lead (soluble forms)	fair to good	95	80	90-99		
Lead (insoluble forms)						
Mercury (inorganic forms)	80	95-98	80	90-97	99	
Mercury (organic forms)	>80	95-98	80	90-97		-
Nitrate		97-99	80	90-97		
Selenium (+4)		95-97	80	90-97		
Selenium (+6)		95-97	80	90-97		
Silver	good	95	80	90-97		
Radium		95-98		95		
Beta and photon emitters		75-96		90-99		
Copper		95	80	90-97		
Iron	fair to good	95	80	90-99		90
Manganese		95	80	90-99		90
Sulfate		97	80	99		
Total dissolved solids		up to 99	50-90	80-99		
Zinc		95	80	90-99		
Color	100	100		99	50-95	

Source: Black and Veach, Inc., 1977; U.S. EPA, 1977a; Volkert, 1974.

Table IV-7

APPROXIMATE PERCENT ORGANICS REMOVED BY WATER TREATMENT PROCESSES

				2, 4-D Reduction			
Process	Endrine Reduction	Lindane Reduction	Toxaphene Reduction	Sodium Salt	Isopropyl Ester	Butyl Ester	Isooctyl Ester
Coagulation, filtration	35	<10	<10	<10	<10	<10	<10
Coagulation, filtration, and adsorption with:							
Powdered activated carbon, mg/l:							
5-9	85	30	93	-	-	-	-
10-19	92						
	80	55	-	-	90	90	90
20-29	94	80-90	-	-	-	-	-
30-39	-	-	-	90	-	-	-
40-49	-	-	-	-	97	97	-
50-59	98	-	-	-	-	-	97
70-79	-	99	-	-	98	-	-
Granular activated carbon, 7-5-minute full bed contact time	>99	>99	-	-	-	-	-
Oxidation:							
Chlorine, mg/l:							
5	<10	<10	-	-	-	-	-
8	-	<10	-	-	-	-	-
50	-	<10	-	-	-	-	-
100	-	-	<10	<10	<10	<10	<10
Ozone, mg/l:							
11	-	<10	-	-	-	-	-
38	-	55	-	-	-	-	-
Potassium permanganate, mg/l:							
10	-	<10	-	<10	<10	<10	<10
40	-	<10	-	-	-	-	-

Source: U.S. EPA, 1977a.

St. Petersburg, Florida, and Grand Canyon Village, Arizona. These reuse systems also accomplish conservation of potable water supplies. The only instance of direct reuse for potable purposes is at Windhoek, Namibia. The advanced system employed at Windhoek includes polishing ponds, pH adjustment, algae flotation with alum, foam fractionation, lime flocculation, breakpoint chlorination, sedimentation, rapid sand filtration, activated carbon absorption, and chlorination. The reclaimed water is blended with the normal potable supply.

The principal problems associated with advanced treatment processes are high cost of construction and operation, increased complexity of operation, large requirements for resources such as energy and chemicals, and increased amounts of wastewater sludge that require disposal.

Land treatment processes offer an alternative approach to wastewater treatment with significant advantages in some locations. These processes can result in either a percolation of treated effluent to groundwaters or a discharge to surface waters. The three principal processes -- slow rate, rapid infiltration, and overland flow -- are defined as follows:

- Slow rate is the application of wastewater to croplands, forest lands, or landscaped areas for treatment or reuse by irrigation. Treated water percolates to groundwater or it may be collected in underdrains for surface discharge such as at Muskegon County, Michigan.

- Rapid infiltration is the application of wastewater to permeable soils for treatment as it passes through the soil. Treated water usually percolates to groundwater or is indirectly discharged to surface water by lateral flow and seepages. Wells or underdrains may be used to recover the water for surface water discharge or reuse.

- Overland flow is the application of wastewater to relatively impermeable soils for treatment as it flows in a thin sheet down vegetated slopes. Treated water is collected at the bottom of the slopes and discharged to surface waters.

Land treatment processes require relatively large areas of land and are feasible only when suitable land is available at reasonable cost. If a crop can be produced, income from sale of the crop can offset other costs. A significant disadvantage in some areas is the fact that land treatment is water consumptive and its use may deprive a downstream user of water which is his under state law as discussed in Chapter III. When otherwise suitable, land treatment can produce an effluent superior to that from other advanced treatment processes at a substantial saving in cost.

3. Nonpoint Source Control

Pollution from nonpoint sources includes products of decaying vegetation and salts dissolved from the rock and soil; sediment eroded from the land; pesticides, fertilizers and other chemicals introduced by agriculture and silviculture; washoff from roads and streets by storm runoff; and various compounds from mine drainage.

In terms of volume, sediment is generally the major contaminant from all types of nonpoint sources. However, other pollutants which constitute a potential health hazard are more important with respect to the deterioration of drinking water supplies. In this context, the major pollutants from nonpoint sources include pesticides, nitrates, pathogens, organic chemicals, and heavy metals, especially lead. The impact of a particular pollutant depends on the nature of the contaminant, the levels at which it is present, and the effectiveness of water supply treatment methods. Some idea of the magnitude of nonpoint source pollutants can be gained by comparing the export of phosphorus and nitrogen from selected basins in the Northeast. Mean phosphorus loading for agricultural areas was highest at 31 $kg/km^2/yr$ with urban areas at 30 $kg/km^2/yr$ and forested areas the lowest at 8 $kg/km^2/yr$ (EPA, 1975). Nitrogen loading showed the same general relationship with the highest loading from agricultural areas (982 $kg/km^2/yr$) and the lowest from forest (440 $kg/km^2/yr$) (EPA, 1975). The relative pollutant contribution of nonpoint versus point sources will vary from one state to another depending on land use, geology, climate and other factors. One study in Iowa showed that over 90 percent of the annual phosphorus and nitrogen loads in most of the state's rivers was from nonpoint sources (EPA, 1975).

Controls to minimize nonpoint pollution are usually management practices. Management practices to minimize pollutant discharges in urban runoff range from prevention measures such as litter control and street sweeping to retention and treatment of the stormwater. The benefits of the preventive measures are cleaner neighborhoods as well as reduced surface water pollution. The potential benefits of stormwater retention and treatment in water-scarce areas include reuse of the water for recreational lakes, groundwater recharge, or water supply augmentation.

Management practices in agriculture include minimum tillage, terracing, diversions, stripcropping, contouring, and grassed waterways to minimize erosion. Erosion can remove nutrients and pesticides with the sediment. Application of the minimum necessary amount of agricultural chemicals, and avoiding overspray on streams, are also important management practices.

Successful implementation of management practices may require legislation, ordinances, or public education to increase public awareness of the problem. Some states have passed appropriate legislation on soil erosion. Other states have passed laws to regulate mining and reclamation activities and to control abandoned mines. Other improvements in nonpoint source problems can be implemented through Federal legislation, such as the Surface Mining Control and Reclamation Act and the Clean Water Act -- i.e. Areawide Wastewater Management Planning (Section 208) -- and specific EPA enforcement actions.

Another consideration in nonpoint pollution control is the effect of controlling the activity which is causing the pollution. Examples of such tradeoffs are loss in food production if less chemical fertilizers and pesticides are used and lower coal output of strict environmental regulations for coal mines are enforced.

D. Water Quality Problems

1. Drinking Water

Establishing standards does not automatically guarantee compliance. For example, the most recent information on compliance with the microbiological MCL in the Primary Drinking Water Standards is summarized in Table IV-8. It is clear that water supply systems of all

Table IV-8

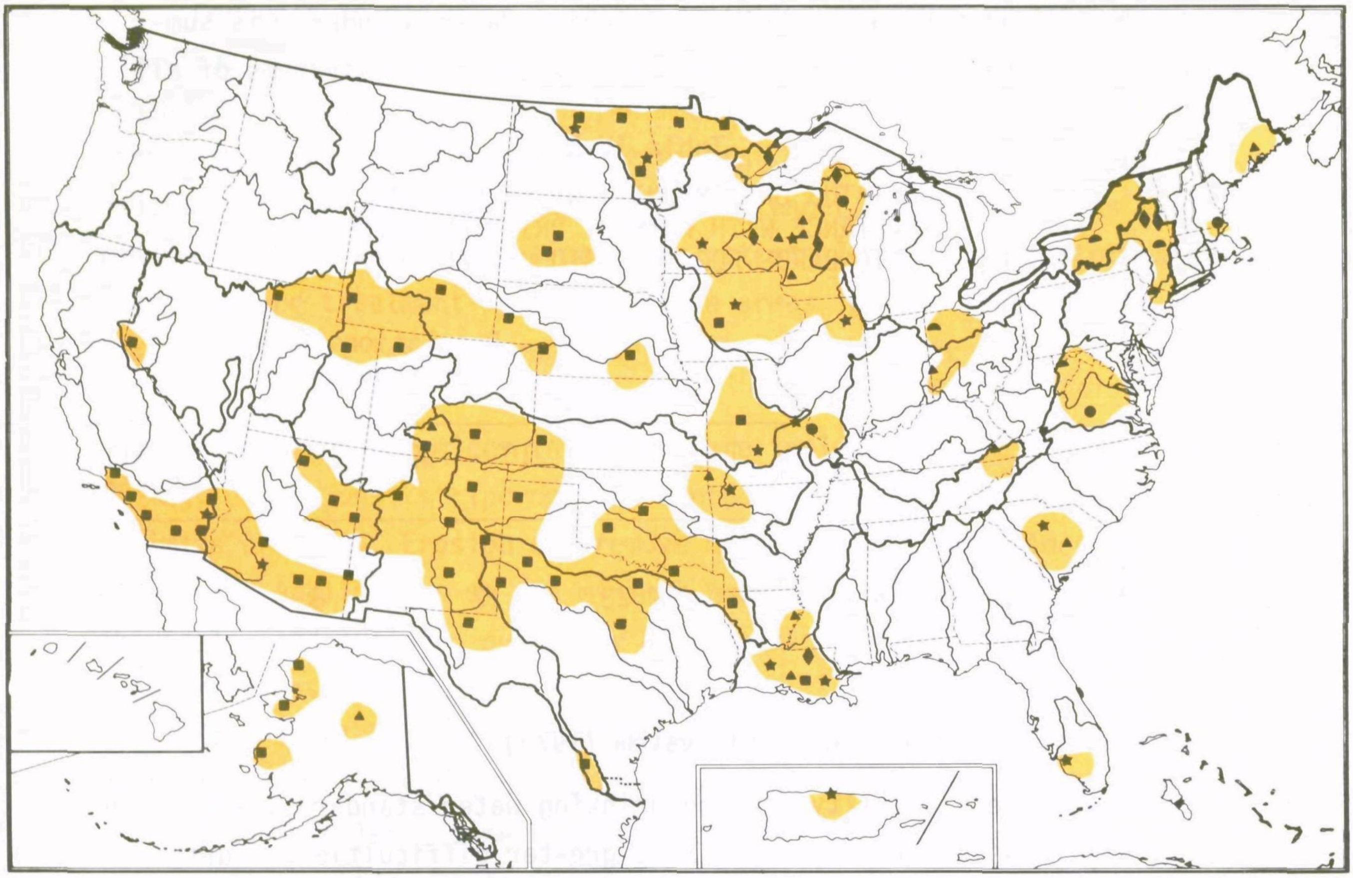
STATUS OF COMMUNITY WATER SYSTEM
COMPLIANCE WITH PRIMARY DRINKING WATER
STANDARDS FOR MICROBIOLOGICAL MCL

	Population Served (in thousands)				
	1	1 - 10	10 - 100	100	All Systems
Systems in violation, as % of all systems in size category	24	23	12	8	23

Source: Federal Reporting Data system (1979)

sizes have some difficulty meeting drinking water standards, and furthermore, smaller systems in general have greater difficulties. Further evidence of both of these points is provided in the results of a 1969 Community Water Supply System Study (USPHS, 1969) as shown in Table IV-9. The "mandatory" and recommended limits correspond fairly closely to the primary and secondary standards presently in use or proposed.

Evidence of the extent of drinking water source pollution is contained in WRC (1978) which identifies water quality problems for domestic supply as reported by Federal and State/Regional Study Teams. An indication of the problem locations is given in Figure 4.1. As shown in the Figure, saline water is the most common problem with drinking water; i.e., in the Southwest U.S., Great Basin, and Great Plains, natural salt springs and saline groundwater are common, causing both surface and groundwater to exceed the standards. Saline return flows from agriculture augment this natural salinity. In the Eastern U.S., locations with heavy metals, chlorinated hydrocarbons and industrial chemicals are evident in Figure 4.1 and generally represent a potential for violations of one or more of the primary standards.



Explanation

Area problem

Area in which existing or potential pollution of domestic water supply was reported

Unshaded area may not be problem-free, but the problem was not considered major

Specific sources of pollution

● Industrial chemicals other than chlorinated hydrocarbons

♦ Chlorinated hydrocarbons from treatment processes and energy development

▲ Heavy metals (e.g., mercury, zinc, copper, cadmium, lead)

★ Coliform and other bacteria

■ Saline water

◓ General municipal and industrial wastes

Boundaries

Water resources region

Subregion

Figure 4.1 QUALITY OF DRINKING WATER PROBLEMS

Source: WRC (1978)

Table IV-9

STATUS OF SURVEYED WATER SUPPLY SYSTEMS

Number of Systems:	446	501	22	969	(total)
Population Group Served: (in thousands)	<.5	.5-100	>100	18,203	
Evaluation of Systems:					
. Met standards	50%	67%	73%	59%	
. Exceeded recommended limits	26%	23%	27%	25%	
. Exceeded mandatory limits	24%	11%	0	16%	
Study Population (in thousands)	88	4,652	13,463	18,203	

Source: U.S. Public Health Service (1968)

Dissolved salts, heavy metals, and chlorinated hydrocarbons are relatively difficult to remove from water and the organics are difficult to detect, especially in low concentrations. The smaller water systems are at a special disadvantage with respect to these materials. Removal of dissolved salts requires relatively expensive desalting equipment such as for electrodialysis or reverse osmosis processes. When salinity of a water supply is only moderately above the recommended limit of 500 mg/l and the supply has been in use for many years, it is difficult to convince either operator or consumer that the expense is warranted. If salinity reaches levels which are offensive to taste, corrective measures are usually taken such as at Key West, Florida, Coalinga, California, and in the Virgin Islands.

The pollutants from industry and/or mining -- organic compounds, heavy metals, and industrial chemicals -- are a much different problem. Such compounds are potential health hazards. They are also relatively difficult to detect and may require expensive processes for removal.

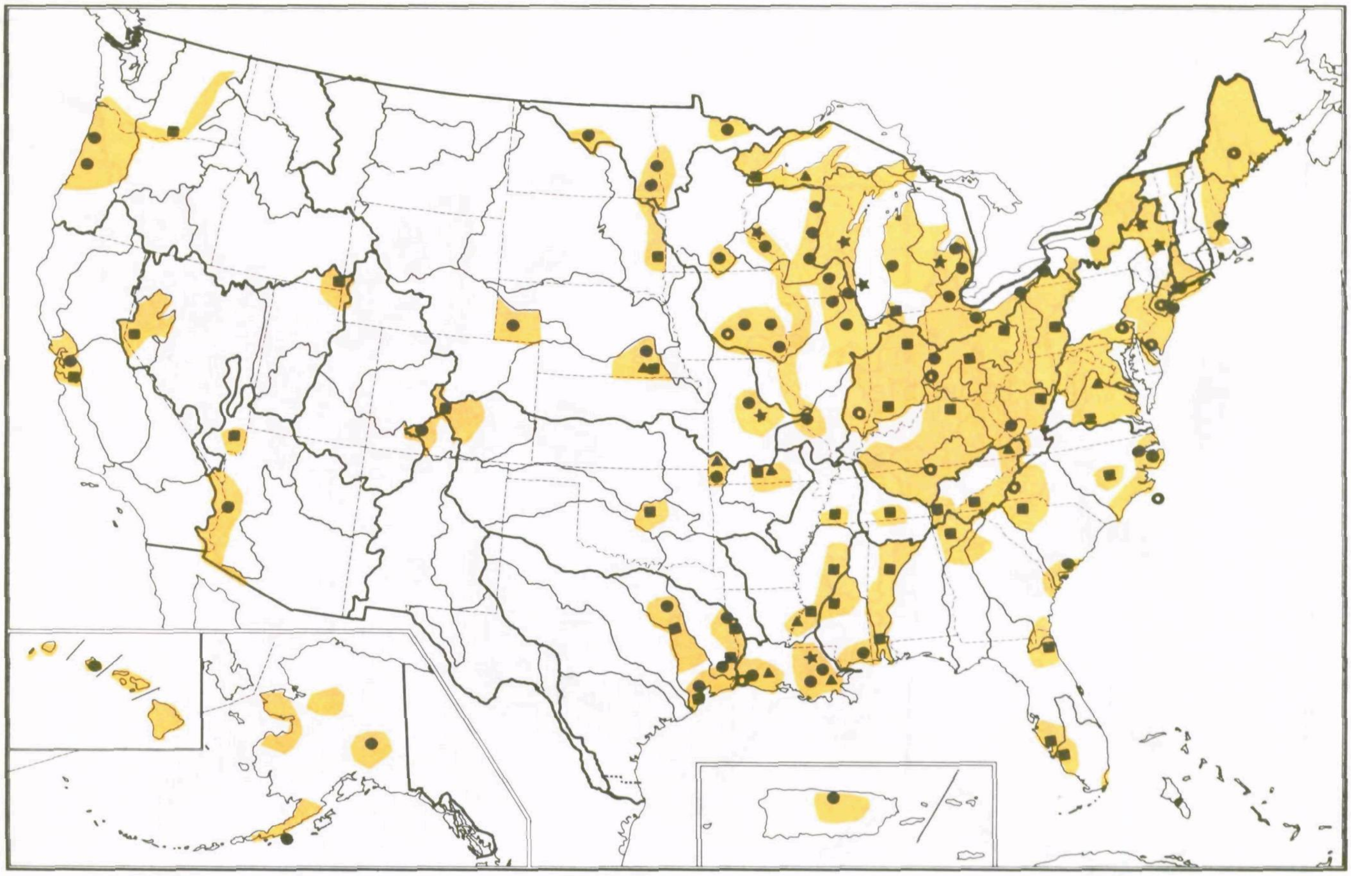
The very largest systems with well-equipped laboratories and large treatment plants are generally able to detect and remove these pollutants. However the smaller systems usually have no laboratory and monitor their product by sending one sample monthly to a commercial laboratory. They are much less likely to detect the presence of pollutants and, if detected, their treatment system which may consist of a settling basin to remove turbidity and chlorination to control coliform bacteria would be unable to remove contaminants such as heavy metals.

2. <u>In-stream Quality</u>

Figures 4.2, 4.3 and 4.4 identify areas of surface water pollution as reported to the WRC by Federal and State/Regional Study Teams. Pollutants, introduced by point sources, are primarily nutrients and coliform bacteria from municipal waste or feedlot drainage, and are primarily found in the eastern states where isolated cases of heavy metals and industrial chemicals are also reported (see Figure 4.2). As shown, Alaska also has problems with nutrients and coliform bacteria. Pollution from nonpoint sources (see Figure 4.3) is dominated by herbicides, pesticides and other agricultural chemicals in the eastern states with acid mine drainage in second place. Hawaii also has problems with agricultural pollutants. In the western states the primary nonpoint pollutants are dissolved salts derived from irrigation return flows with a few cases of agricultural chemicals in second place.

Eutrophication (see Figure 4.4) is the result of build-up of nutrients in a lake or slow moving stream. These nutrients support a vigorous crop of algae and shoreline vegetation. Decomposition of dead vegetation releases more nutrients to the water and may also seriously deplete oxygen. Eutrophication is frequently a natural process which may be accelerated by nutrients introduced by man. This "cultural" eutrophication has occurred to some extent in nearly all parts of the country, but it could be controlled.

Nutrients released to the streams come primarily from municipal wastes, agricultural drainage, industrial wastes and feedlot drainage and these sources are augmented by natural nutrients delivered to



Explanation

Area problem

Area in which significant surface-water pollution from point sources is occurring

Unshaded area may not be problem-free, but the problem was not considered major

Specific types of point-source pollutants

● Coliform bacteria from municipal waste or feedlot drainage

★ PCB (polychlorinated biphenyls), PBB (polybromated biphenyls), PVC (polyvinyl chloride), and related industrial chemicals

▲ Heavy metals (e.g., mercury, zinc, copper, cadmium, lead)

■ Nutrients from municipal and industrial discharges

○ Heat from manufacturing and power generation

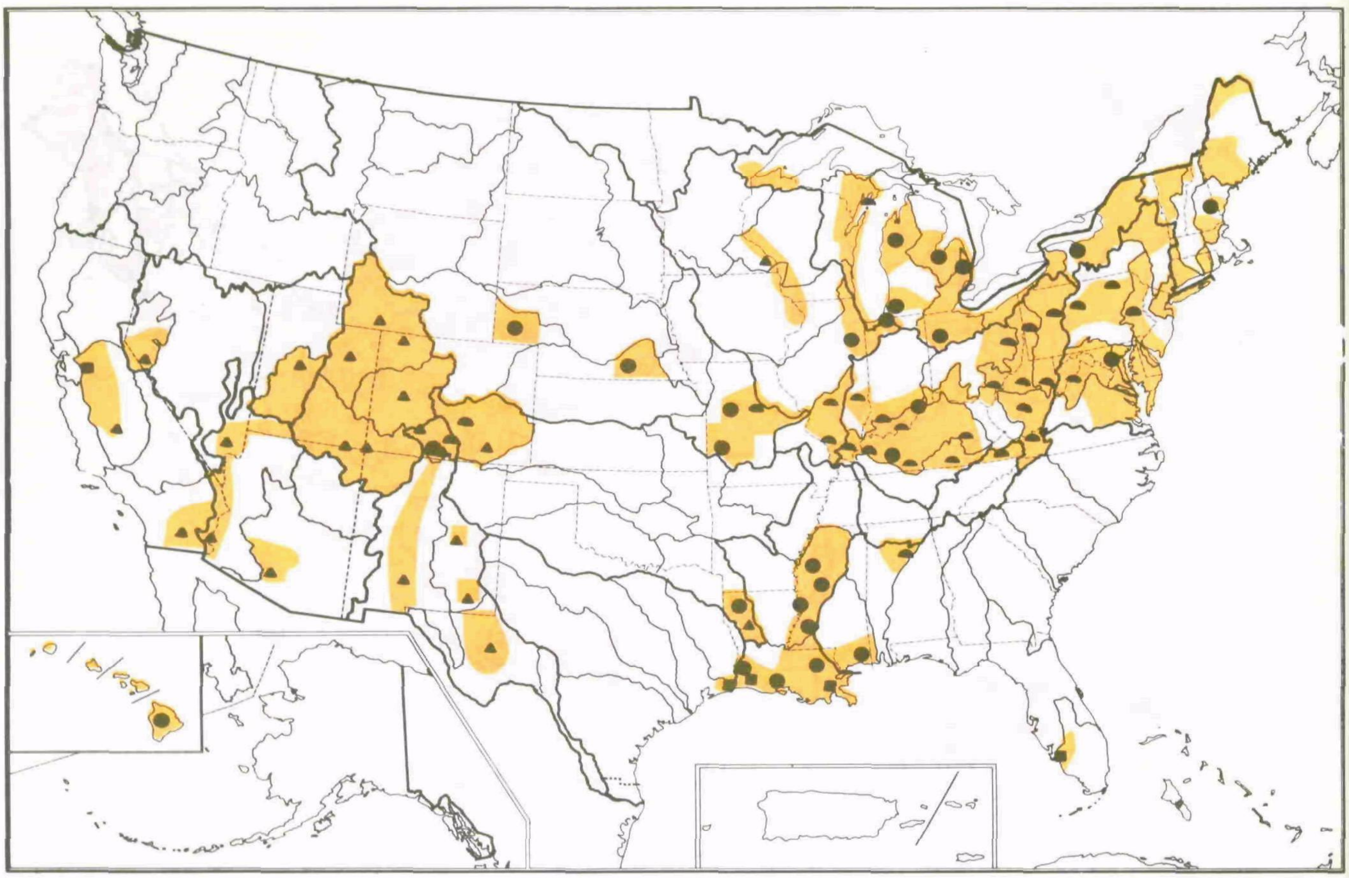
Boundaries

Water resources region

Subregion

Figure 4.2 SURFACE-WATER POLLUTION PROBLEMS FROM POINT SOURCES (MUNICIPAL AND INDUSTRIAL WASTE)

Source: WRC (1978)



Explanation

Area problem

Area in which significant surface-water pollution from nonpoint sources is occurring

Unshaded area may not be problem-free, but the problem was not considered major

Specific types of nonpoint-source pollutants

- ● Herbicides, pesticides, and other agricultural chemicals
- ▲ Irrigation return flows with high concentration of dissolved solids
- ■ Sea-water intrusion
- ◓ Mine drainage

Boundaries

- —— Water resources region
- —— Subregion

Figure 4.3 SURFACE-WATER POLLUTION PROBLEMS FROM NON-POINT SOURCES (DISPERSED)

Source: WRC (1978)

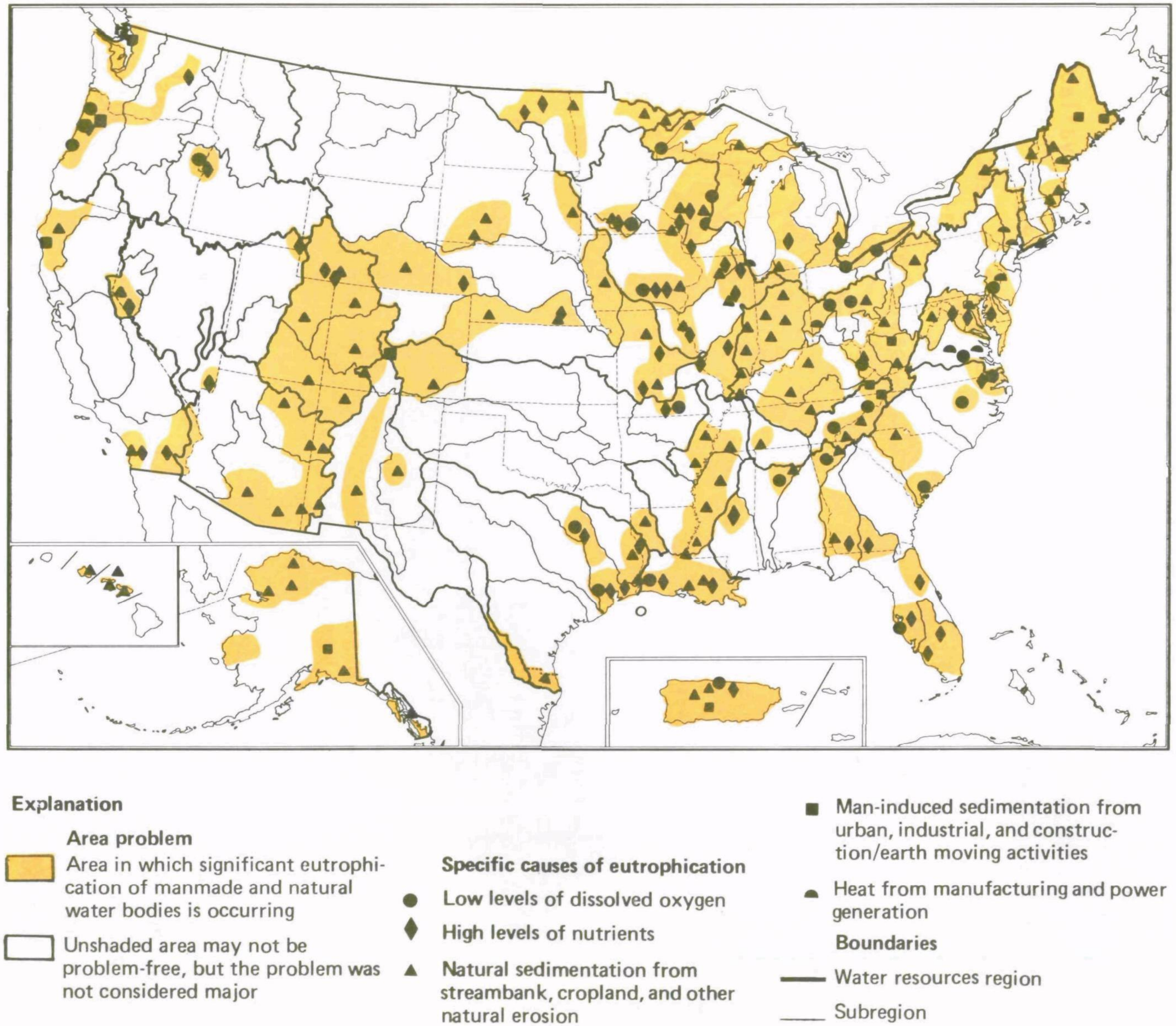


Figure 4.4 SURFACE-WATER POLLUTION PROBLEMS - EUTROPHICATION

Source: WRC (1978)

the stream as a result of man-induced erosion. Removal of these materials from wastewater requires special treatment procedures.

The reasons for water pollution in excess of standards are manifold. In some cases industries or cities have not yet completed treatment systems required for compliance with NPDES permits. A completed treatment plant requires a skilled operating staff which is not yet available to all plants. Inadequate pretreatment of industrial wastes may bring pollutants to a municipal plant which are not detected and, hence, not removed. Control of nonpoint sources is especially difficult. The 1977 Water Quality Inventory (EPA, 1977e) reports 246 basins affected by nonpoint source pollution distributed among sources as indicated in Table IV-10.

Table IV-10

PERCENTAGE OF BASINS AFFECTED BY TYPE OF NONPOINT SOURCE

Source	Percent
Urban Runoff	52%
Construction	9
Hydrologic Modification	15
Silviculture	15
Mining	30
Agriculture	68
Solid Waste Disposal	14
Onsite Waste Disposal (Septic Tanks)	43

Clearly agriculture, urban runoff, onsite waste disposal and mining are the four leading causes of nonpoint pollution. Very few of the watersheds in the U.S. escape pollution from one of these sources (see Figure 4.5). Criteria for agricultural management practices are needed and enforcement will be required. Some controls on urban runoff are also required but must be introduced selectively since they will be quite expensive in some cases.

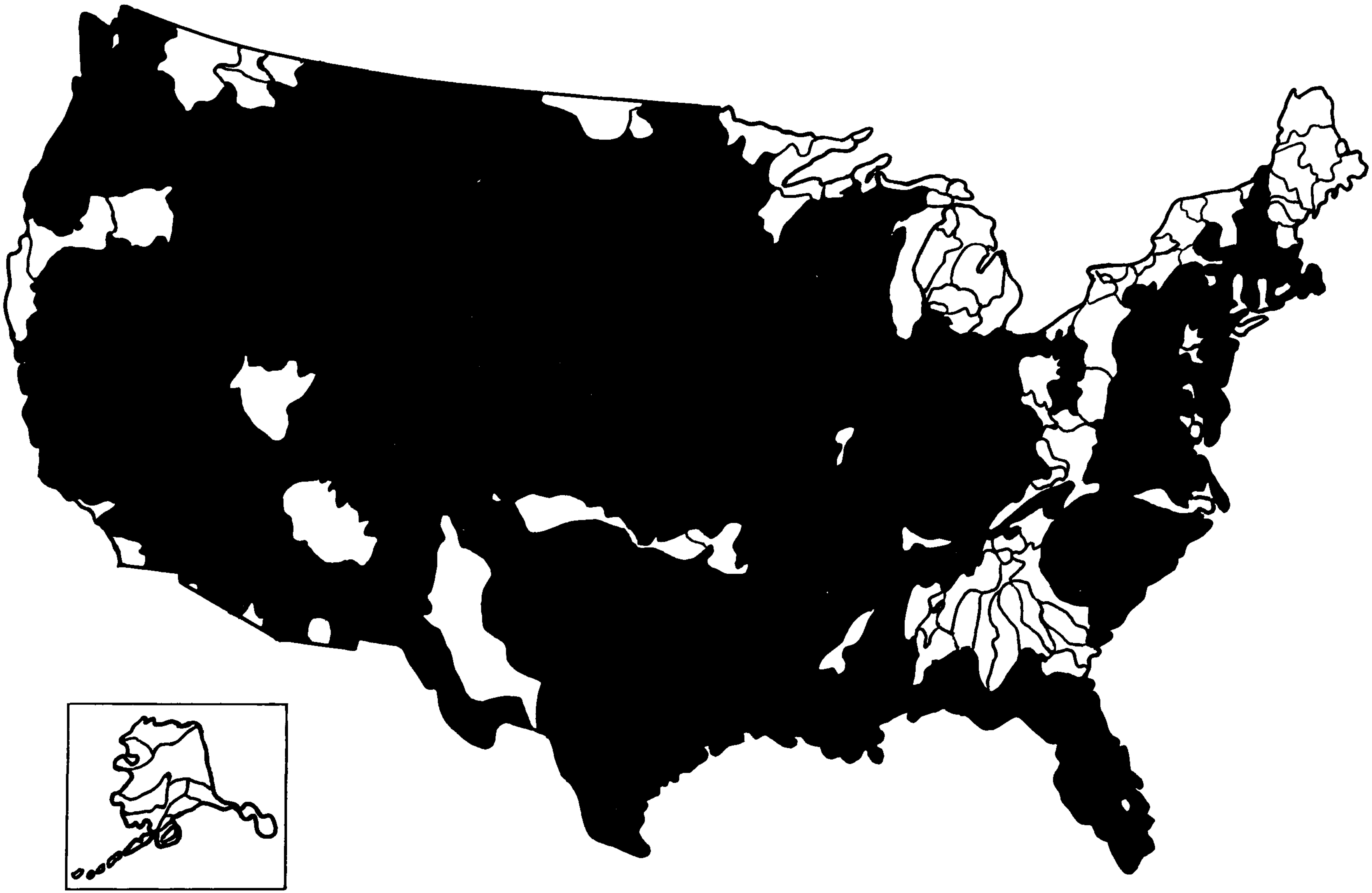


Figure 4.5 BASINS AFFECTED IN WHOLE OR IN PART BY POLLUTION FROM AGRICULTURAL ACTIVITIES

Source: National Water Quality Inventory, 1977 Report to Congress

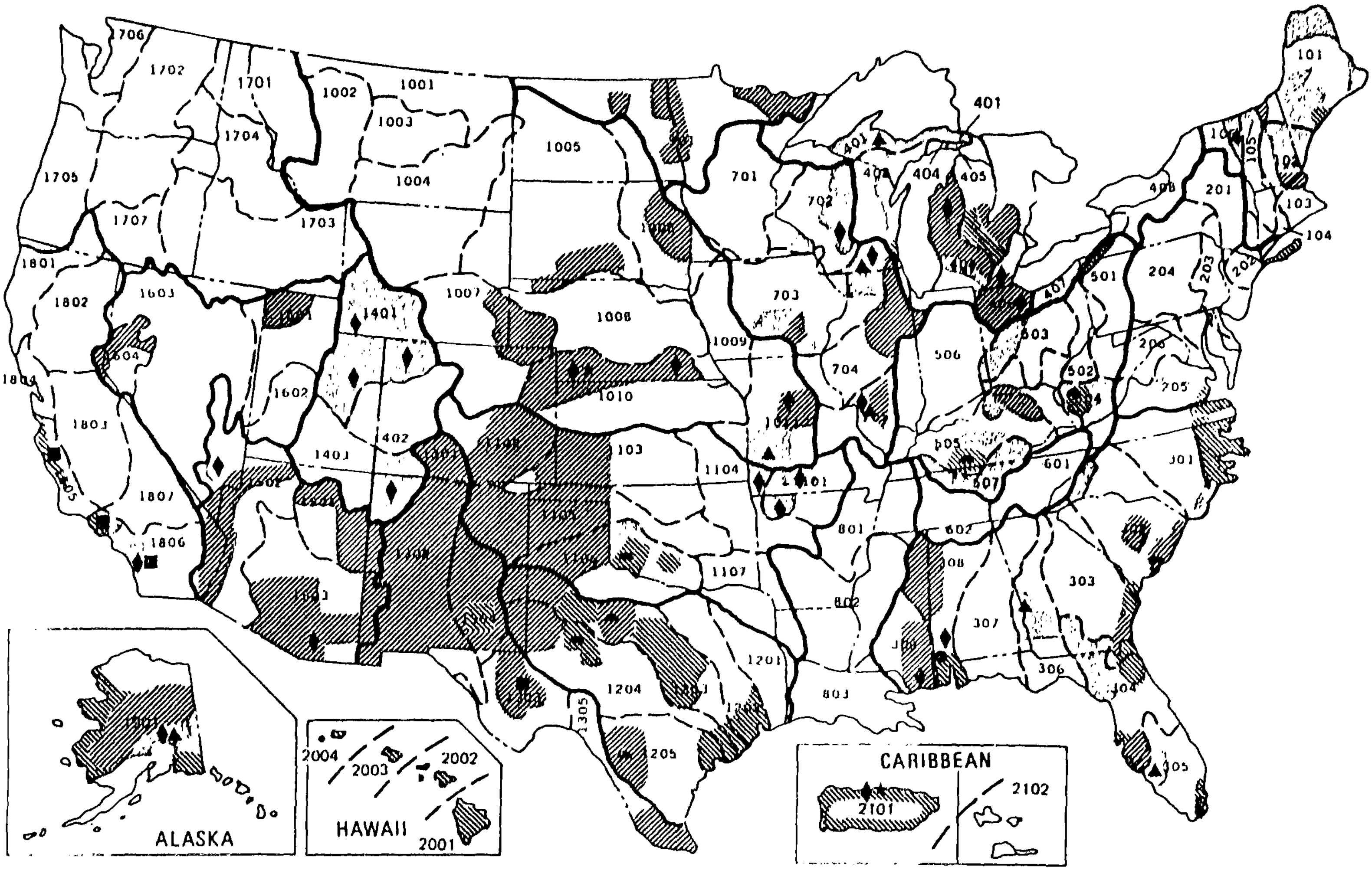
Onsite individual disposal of wastewater, most commonly by septic tanks, can be reduced by provision of central wastewater treatment facilities. Again this will prove costly because of collection problems. The problem also focuses on the small towns and villages where per capita costs may be very high. Not all septic systems are deficient and need replacement and widely dispersed systems in rural areas may not be problems, but newly developing suburban areas with closely spaced housing can be problems especially if slopes are steep and soils are thin.

The fourth major cause of nonpoint pollution is mining -- both surface mining and underground. For the most part this can be regulated with proper laws requiring control and recent legislation should be effective as soon as programs are implemented. Abandoned mines are, however, a special problem as there may be no owner against whom laws or regulations can be enforced. The Abandoned Mine Fund under the new Surface Mining Control and Reclamation Act should help this problem.

With regard to the other nonpoint sources shown in Table IV-10, it is expected that the Resource Conservation and Recovery Act will lead to reduction in pollution from solid waste sites. Construction activities and hydrologic modification are primarily responsible for erosion. State and local ordinances requiring appropriate controls can greatly reduce the pollution from these causes. Erosion from improperly constructed logging roads is also one of the major sources of pollution from silviculture and is controllable.

3. Groundwater Pollution

Groundwater pollution problems reported to the WRC are displayed in Figure 4.6. Large areas of the country have highly mineralized groundwater from natural causes. Other areas may have moderately high mineral content as a result of leaching salts from agriculture into the groundwater. Leachate from landfills, injection wells, and surface impoundments are the primary factors in the remaining cases of groundwater pollution. The latter type problems are controllable. Groundwater pollution problems will be decreased with proper monitoring and enforcement of



Legend

Areas with Greatest Total Impact

- Areas that have ground water contamination.
- Areas with saline water intrusion (actual or potential) or natural salinity.
- Areas with high levels of minerals or dissolved solids in ground water.

Location of Specific Impacts

- ● Contamination resulting from leaching of municipal and industrial wastes and waste runoff through oil and gas fields and other excavations.
- ♦ Contamination resulting from toxic industrial wastes.
- ▲ Contamination resulting from leaching of wastes from land fills.
- ■ Salt and other chemical contamination of aquifers from irrigation and other agricultural activities.
- ▬ Inadvertent contamination from well drilling, harbor dredging, and excavation for drainage systems.
- ★ Contamination from deep well injection.
- √ Natural radioactivity in ground water.

Figure 4.6 GROUND-WATER POLLUTION PROBLEMS

Source: (WRC) 1978

programs under the Safe Drinking Water Act and Resource Conservation and Recovery Act. Because many small water systems depend on groundwater as a supply, these programs are especially important in mitigating their problems. Water systems using groundwater as a source often have little or no treatment, thus making source protection even more important.

4. Summary/Findings

- A sizeable body of Federal legislation aimed at cleaning up and protecting the quality of the Nation's water resources was created between 1972 and 1977. The laws are broad and strongly mandate that firm controls on pollution be established, in particular as these controls relate to point source polluters. Considerable progress has been made especially with respect to surface water. However full implementation will require more time and resources, improvements in technology, the information base, and in the state-of-the-art as it relates to water quality planning/management, and a continuing commitment to achieve the objectives provided for in the legislation.

- Groundwater has not been as well protected as surface water. As noted in Chapter III, groundwater overdraft has resulted in quality problems with respect to salinity and as observed in this Chapter adverse effects have also resulted from land fills or dump leachate, injection wells, surface impoundments and leaching salts from agriculture. Groundwater is a primary source of supply for many small community systems, some large systems, and for much of the rural population; adequate protection is a national concern as exhibited by legislation such as the Safe Drinking Water Act and the Resource Conservation and Recovery Act. It is important to obtain a better understanding of priority groundwater pollution problems and to pinpoint actions which can be taken under present mandates to ameliorate them.

- The primary and secondary drinking water standards are being reviewed by the National Academy of Science and others. Until the results of these studies and other ongoing research efforts related to health effects on humans or present margins of safety are known, evidence is inconclusive for changing the standards.

- Although it is most probable that land treatment can produce an effluent superior to that from advanced treatment at less cost, it is water consumptive and may adversely impact on a downstream user's water rights. In addition economic benefits are sensitive to other local circumstances such as availability of land at a reasonable price and opportunities to use the effluent for crop irrigation.

- Problems in meeting the drinking water standards and monitoring/reporting requirements occur in water supply systems of all sizes. However, small water supply systems have more difficulties in correcting problems due to factors such as lack of operator training and insufficient funding.

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Chapter V

WATER QUANTITY/QUALITY RELATIONSHIPS

A. Overview of Relationships

Water quantity and water quality are closely related under natural conditions and this relationship generally persists even when quantity or quality are influenced by human activity. The following subsections discuss quantity/ quality relationships as they pertain to surface water and to groundwater. The discussion is drawn from information presented in Chapters III and IV.

1. Surface Waters

Under natural conditions the water quality in a stream will often be at its poorest near the end of a summer dry spell when streamflow is low and temperatures are high. Dissolved oxygen decreases as water temperature increases. Hence during warm periods, the risk of oxygen depletion is higher. Low flows on most streams come from the groundwater and usually contain significant dissolved minerals. Hence, it is at low flows that the mineral content of surface water is highest. Poor conditions will also be observed during and immediately after a rainstorm which produces surface runoff. Under this condition pollutants which are on the ground surface, or on vegetation, will be washed into the stream. Sediment will be the most plentiful pollutant, but agricultural chemicals, rubber, oil and grease from cars, and any other material which may have accumulated on the ground can be present. Commonly sediment which is available in unlimited quantities increases as flow increases, but other pollutants present in limited quantities may be largely removed from the land by a moderate rain and, hence, do not increase indefinitely with increasing flow rates.

In the lower river reaches there is a kind of equilibrium attained between the flow of freshwater into an estuary and the movement of saline water upstream under tidal action. In periods of low flow the salt water front will penetrate farther inland and during periods of flood, freshwater is found much farther downstream in the estuary. Depletion of the freshwater flow by diversion of water upstream during low flow periods can result in further excursion of the salt water upstream, past intakes which normally receive freshwater. The effect may be augmented by flood water storage which reduces the extent of freshwater "flushing" normally experienced in the estuary during floods. The problem is especially serious during drought. The water intake for Philadelphia was threatened by saline intrusion in the Delaware estuary during the drought of the early 60's. Industrial and agricultural intakes along the Sacramento River estuary and in the Sacramento-San Joaquin Delta of California are threatened with salt water during dry years and many intakes have been abandoned. Similar problems have occurred in other estuaries along the U.S. coast.

The common practice of setting in-stream quality standards in terms of the 10-year, seven-day low flow is responsive to the first condition cited above -- i.e. poor water quality conditions near the end of a summer dry spell -- and in particular by pollution with high BOD. In some conditions, however, the worst pollution conditions may occur as the result of storm washoff for which the low-flow standard will be inappropriate.

The assimilative capacity of a stream causes pollutant levels to decrease by one of several mechanisms or processes. As water flows through a stream system some pollutants may settle to the stream bed and be removed, at least temporarily, from the water. Other pollutants may be taken up by vegetation or aquatic life and removed from the water. Oxygen, absorbed through the stream surface, may help to satisfy oxygen demand. These are the processes of self purification. Depletion of streamflow for off-stream uses generally reduces the assimilative capacity and the rate of self purification. In some streams, summer flows are almost entirely effluent discharged to the stream, i.e. without the effluent the stream might go dry. In this case, if a consumptive waste treatment process is introduced -- e.g. land treatment, reuse for irrigation, or lagoon evaporation -- the effluent returned to the stream is decreased and the flow could be reduced to zero.

2. Groundwater

Quantity and quality are also interrelated in the case of groundwater and this relation extends to surface water. Pumping groundwater from wells near a stream may in effect be a diversion of flow from the stream such as along the Platte River in Colorado. Conversely, reduction of streamflow by an upstream diversion may reduce the recharge of an aquifer. Hence, it is not always possible to solve a local water supply problem by shifting from a surface source to groundwater or vice versa.

The quality of groundwater is very directly affected by the quality of water which recharges the aquifer. Movement of polluted water through the soil may strain out the suspended matter including bacteria but dissolved salts will generally remain unaffected. Recharge of groundwater with polluted water can occur in several ways: e.g., injection of polluted water into the aquifer through a waste disposal well, percolation from land disposal systems for wastewater, percolation from a polluted stream, leaching of salts from irrigated farm land, leaching of salts from land fills, from solid wastes, or deliberate recharge of an aquifer with storm or reclaimed water to augment the groundwater supply. Chemicals applied to the land may also be washed into an aquifer with percolating water. This can occur on agricultural land where the watertable is fairly close to the surface. It has also occurred in many locations in the northern states where salt is applied to roads and streets for deicing. Wastewater cesspools and septic tanks can also lead to pollution of the groundwater.

Overdraft of the groundwater may also lead to pollution of the aquifer. Coastal aquifers which extend under the sea are susceptible to intrusion of sea water if the water table in the aquifer is drawn down. Such intrusion has occurred in Southern California and Long Island, New York.

Many aquifers were once below sea level as the oceans have advanced and receded over geologic time. Either salt water or salt deposits may remain in those aquifers. Excessive overdraft on an adjacent freshwater aquifer may permit the intrusion of saline water from the saline aquifer into the freshwater aquifer. Such intrusion has been noted in Texas, Oklahoma, and California.

Groundwater is not, therefore, uniformly a source of pure and safe drinking water. It can be polluted both by natural processes and by the activities of man. Constant surveillance is necessary to avoid conditions under which such pollution occurs.

B. Planning Activities

The U.S. has been engaged in planning for the management of water resources since the turn of the century and a number of planning programs exist. This section augments information presented in Chapter II and IV.

Under Section 106 of the Clean Water Act, two percent of the money allocated to a state for construction grants, or $400,000 whichever is greater, may be available to the state for planning of pollution control activities in general -- i.e., "State Management Assistance Funds". The principal use for such money is the management of the construction grant program but it may also be applied to the NPDES and wetlands permit programs, and management of the 208 statewide water quality planning program.

Section 208 of the Clean Water Act provides for an extensive planning process. Regional planning agencies, where they exist, are responsible for preparing 208 plans, while the states are responsible for planning outside the areas covered by regional planning agencies. The 208 plan was intended to be a comprehensive study of all point and nonpoint pollution sources leading to the development of a cost-effective plan to control these pollution sources using land management, land use controls, and other nonstructural measures as well as conventional waste treatment. A round of 208 studies was completed in 1978 and these studies are still under review by EPA. Periodic updating of the 208 plan is provided for in the Act. As mentioned earlier, EPA has developed regulations for Water Quality Management Planning which consolidate the Section 106, 208, and 303(e) planning programs.

In 1965 Congress passed PL 89-80, the Water Resources Planning Act which established the U.S. WRC and a mechanism for creating River Basin Commissions. The WRC was to establish policies and standards for water resource planning, while the Commissions were to develop river basin management plans. One level of planning specified by the WRC was Level B Plans. These plans are regional or river basin plans at reconnaissance level and are intended to identify long range problems and to resolve them by recommending actions to be taken by various agencies. Section 209 of the Clean Water Act requires preparation of Level B plans for all basins by 1980. These Level B plans could identify problems (or conflicts) between water quantity plans and water quality plans and could screen possible solutions.

C. Water Allocation/Water Quality Coordination Study

Section 102(d) of the Clean Water Act provides: "The Administrator, after consultation with the states, and River Basin Commissions established under the Water Resources Planning Act, shall submit a report to Congress on or before July 1, 1978 which analyzes the relationship between programs under this Act, and the programs by which state and Federal agencies allocate quantities of water.....". Section 102(g) provides further that "...the authority of each state to allocate quantities of water within its jurisdiction, shall not be superseded, abrogated or otherwise impaired by this Act......".

The above-referenced report is under preparation but a final draft has not been released. Some examples of the relationship between the control of water quality and the allocation of water quantity have already been noted in this report but perhaps bear repeating here. Consumptive waste treatment technologies could reduce streamflow below the level needed to satisfy existing water rights. Pollution of groundwater from any cause could make the water unfit for use and, in effect, deprive prospective users of the ability to use the groundwater. Restrictions in discharges to a stream, especially during drought periods could reduce flows below those desirable for in-stream uses. The report also reviews state water rights law and points out implications for water quality.

D. Problem Areas in Water Quantity/Water Quality Coordination

1. Groundwater Withdrawals

As has been noted earlier, excessive withdrawals of groundwater (mining) not only deplete the water resource and increase energy use for pumping but also create a situation in which pollution of the aquifer may be introduced by intrusion of saline water, induced percolation of polluted water from streams or induced percolation of water seeping through landfills and dumps. Such pollution of the groundwater can make it unfit for many uses. For example highly saline water can be unsuitable for domestic use, for irrigation, for process water in many industries, for boiler feedwater and even for cooling water.

Although many would argue that mining of groundwater may be no more inherently wrong than mining for minerals, there is general agreement that mining in such a way as to induce pollution and degrade the resource is wrong. Indeed it has been argued that the states should have appropriate provisions in their water codes to preclude such an event. Several technical procedures are available to avoid induced pollution. Limiting the rate of groundwater withdrawal to a level such that induced pollution will not occur is generally preferable, but elimination of the pollution source is effective if feasible. Wells can also be located so as to avoid, or at least delay, the development of conditions leading to induced pollution. The use of artificial recharge to augment the water yield of the aquifer and at the same time to minimize the likelihood of an intrusion of polluted water is also possible in many cases.

2. Surface and Groundwater Relationships

Groundwater and surface water are closely related phases of the hydrologic cycle. In many areas natural recharge to groundwater takes place primarily through the seepage of water from surface stream channels to the groundwater. This is a common condition in most of the arid Southwest. On the other hand, streamflow may be groundwater fed to the stream from springs or seeps. Without such groundwater flow to sustain the streams, most of them would be dry during protracted dry periods unless reservoir storage was used to sustain the flow.

As noted in Chapter II, most water codes treat the surface and groundwater as if they were separate and unrelated. Thus it is possible to obtain an appropriative right to divert water from a surface stream and, hence, to reduce the recharge of the groundwater. It is also possible to obtain a permit to pump water from wells adjacent to a stream and thus to deplete the surface streamflow. In some states it would not even be necessary to apply for a permit for the well. This situation poses a special threat to small water supply systems who may note a progressive depletion of their source which the supplier cannot control. To counteract this problem, water codes would have to recognize the relationships between surface and groundwater and treat them in such a way that the best use of the total resource is assured.

3. Artificial Recharge of Groundwater

Depletion of the groundwater occurs in some cases because the natural recharge is very low despite the availability of a relatively abundant surface supply. This condition will occur when the opportunity for recharge is restricted. Any condition that makes for low rates of infiltration through the soil will limit recharge of groundwater to that which can percolate from stream channels. Heavy clay soils, relatively firm unweathered rock, terrain that has been compacted by heavy vehicle traffic, or the process of urbanization which increases the land covered by impervious surfaces, will reduce or eliminate significant infiltration of rainfall. If the bed and banks of the streams are also relatively impermeable for any of these reasons, most of the rainfall will leave the area as surface flow, often as flood flow. Practices which encourage infiltration such as forestation, and contour plowing or terracing of agricultural land, are examples of deliberate steps to encourage percolation of runoff which will increase the recharge to groundwater.

There are other more elaborate practices designed to increase the recharge of groundwater. Water can be pumped into an aquifer. Where the aquifer or a connecting pervious soil layer is near the surface, excavation of a pit down to the pervious material may provide a mechanism for increased percolation of water. Scarifying the land surface or stream beds to break up thin layers of impermeable material, and ponding water on natural outcrops of pervious soil or rock which can convey the water to the groundwater, are possible means of recharge.

If the lack of natural recharge results mostly from a lack of rainfall and surface water, artificial recharge will require that the recharge water be imported from an area of surplus. The various means mentioned above can be used to percolate the imported water. Areas of true water surplus are becoming rare in the U.S. and importation may not necessarily be feasible. In principle, water should not be exported from an area if it is needed to maintain in-stream uses, recharge groundwater, or to provide a "cushion" against drought.

Artificial recharge projects are often large, requiring relatively costly facilities and continued careful operation. They require careful planning including investigation of the underlying geology, analysis of the adequacy of water supply and a study of the quality of available water. A high bacterial count may lead to bacterial slimes which can plug well screens. Fine sediments can plug stream gravels or the soil and rock of a recharge area. Dissolved salts in the recharge water will penetrate the groundwater and may increase the salt content depending on the source of recharge water. This may include toxic compounds as well as the more common dissolved minerals. Boron compounds from soaps may make the water unsuitable for agricultural use. Nitrates in sewage effluent are a health hazard for infants.

If all features of the project are sound, land application of wastewater can be a far cheaper method of keeping pollutants out of the streams than an AWT alternative. Additionally in some instances land application of wastewater represents a savings in water use, contributes some nutrients to the soil, and may offer a source of income from the crops produced.

4. Treatment Technology

Several different treatment systems are available for the management of wastewater quality and each has a different impact on quantity. Broadly they fall into two classes: biological treatment which is nonconsumptive, and water consumptive treatment systems. The effluent from biological treatment is discharged to a stream or other water body carrying with it a small residual of the original pollutants or their transformed products. The material removed from the wastewater during treatment remains as a sludge which must be disposed of or becomes a gas which is released to the atmosphere or, in the case of methane may be used as a fuel.

Consumptive treatment consists usually of removing suspended materials followed by spreading the remainder over land or holding it in a lagoon. The liquid effluent is largely evaporated or transpired to the atmosphere from the soil or lagoon. Some of the water spread on land may percolate into the soil and reach the groundwater or be discharged to a stream. In its travel through the soil most of the suspended matter will be removed but dissolved material will be carried with the water. The evaporated water leaves as vapor and the material which was dissolved in it will be left in the soil or lagoon. Because of the evaporation, a significant part of the wastewater is removed from the hydrologic cycle, i.e. is consumed, and need not be discharged to a water body. By reducing the streamflow within a watershed, the concentration of materials in the remaining flow may be increased to levels in excess of that permitted by stream standards. Generalization regarding the consequences of the various waste treatment alternatives is uncertain because the performance is very much affected by the local conditions.

Heat is considered a pollutant and a specific example of the water consumptive-nonconsumptive alternatives is found in the case of disposal of waste heat from a thermo-electric power plant. The system widely used in the past has been to take water from a river or lake, pass it through the condensers where it absorbs heat, and discharge the heated water immediately back to the stream or lake which was its source. This is known as once-through cooling. The hot water mixes with the cooler water of the source and there is relatively little additional evaporative loss as a result of the heating. Evaporative loss in once-through cooling is estimated at 2 percent of withdrawal.

As a replacement for once-through cooling, cooling towers or cooling ponds are required. These alternatives dissipate heat primarily by the evaporation of water from the surface of the cooling ponds or the cooling tower. Thus the consumptive use of water is increased substantially. General guidelines indicate that wet cooling towers would consume approximately 30 cfs per 1000 MWe, once-through systems from 1-10 cfs per 1000 MWe and cooling lakes from 10-20cfs per 1000 MWe depending on ambient temperatures, humidity and wind speed. (USGS Circular 745, 1977).

5. Intake-Discharge Locations

Water intake vis a vis wastewater discharge location is a less straightforward topic than it appears to be at first glance and a complete characterization of the relationship depends on site-specific circumstances. One argument advanced is that a higher level of treatment at the point of discharge could reduce the cost of treatment at the water supply intake. However, even if a municipal wastewater were treated to the purity of distilled water before it is discharged into a stream, a downstream water utility would still have to provide treatment for the water it diverts and in most cases their cost of treatment would not be greatly changed. Nonpoint source pollution in the intervening reach would force such treatment. Only if the intake is a short distance downstream of the wastewater discharge and is a major fraction of the flow does the degree of wastewater treatment make a significant difference in the required treatment for the water supply. Even then the problem could be solved by moving the intake upstream of the wastewater discharge.

It is important that toxic materials such as organic poisons or heavy metals such as lead and mercury be prevented from reaching the stream as these materials might easily pass through a water treatment plant. Beyond this, wastewater treatment is primarily for the purpose of maintaining a specified water quality in the stream so that the goal of "fishable and swimmable waters" can be attained. Since the toxic compounds impair the attainment of this goal, they should be prevented from entering the receiving water in any case. It can generally be said that if wastewater flows are treated to a level which meets desirable in-stream standards, there will be little reason to increase the treatment level to achieve a better water supply, except in special situations.

E. Summary/Findings

This chapter discusses the relationships between water quantity/ quality of surface and groundwater and gives examples of areas where interactions occur. Findings include:

- The major areas of overlap for surface waters are the impacts on quality of large diversions, consumptive waste treatment, groundwater withdrawals, and recharge.

- The major areas of overlap for groundwater are the impacts on quality of excessive pumping, artificial recharge, urbanization, and consumptive waste treatment technology.

- The location and flow magnitude of a water supply intake relative to a wastewater discharge location is another area where interrelationships can occur.

Chapter VI

COST, FINANCING AND ENERGY CONSIDERATIONS

A. Water Supply

1. Cost

The delivery of an adequate and dependable supply of drinking water entails a number of costs, from source development, withdrawal and transmission through treatment, storage and distribution. To put these costs into perspective, it is instructive to first examine very briefly the water supply "industry". The most recent estimates place the number of community water systems (those serving 25 or more people, or having at least 15 service connections) at slightly more than 61,000 (FRDS, 1979) and of noncommunity public systems (serving primarily transient population) at about 160,000. Of the population served by community water systems, over 80 percent is supplied by about 5 percent of the systems, while the remaining 95 percent of the systems are relatively small, each serving less than 10,000 population. It is estimated that publicly owned systems make up 56 percent of the total and serve 84 percent of the population, while private or investor owned systems make up the remaining 44 percent but serve only 16 percent of the population (Temple, Barker, and Sloane, 1977). Privately owned systems predominate only in the very small systems serving less than 500 people.

There are a variety of accounting systems in use in the water supply industry making a detailed comparison of costs difficult. Table VI-1 presents some estimates based on a recent study of 984 water systems (Temple, Barker and Sloane, 1977). Data have been grouped by size of system to show how costs change as size changes. Both publicly owned and investor owned systems were included in the survey; although costs for privately owned systems were slightly higher than for the public systems because of taxes, data on both types are aggregated in Table VI-1. Operating expenses such as for energy, labor, and chemicals range from 77 cents per 1000 gallons served for the small systems to 31 cents per 1000 gallons for the largest systems. Interest and

Table VI-1

COMPARATIVE COSTS OF WATER SUPPLY

	Population Served			
	<1000	1000-10,000	10,000-100,000	>100,000
Number	22,954	8992	2442	243
Pop. Served (Millions)	6.6	26.7	73.8	85.1
Operation cents/1000 gal.	77	60	40	31
Interest cents/1000 gal.	15	10	7	5
Depreciation* cents/1000 gal.	21	7	5	4
Assets - Mean Dollars/1000 gal./yr.	14.52	9.47	4.84	3.49
Assets Dollars per Connection	342	382	482	505

*Privately Owned Systems

Source: Temple, Barker and Sloane (1977) depreciation range from 36 cents per 1000 gallons to 9 cents per 1000 gallons or from 48 to 38 percent of operating costs with the highest capital expense burden on the smaller systems.

A comparison of mean assets per system as a function of system size per 1000 gallons of water delivered annually, shows assets varying from $14.50 for the smallest systems to $3.40 for the largest. If assets are expressed as cost per connection, costs are greater for the large systems.

Another study (Clark, Gillean, and Adams, 1977) found that operating costs for medium to large systems averaged about 29 cents per 1000 gallons in 1975. This cost is distributed by purpose in Table VI-2.

Table VI-2

BREAKDOWN OF OPERATING COSTS FOR MEDIUM TO LARGE SYSTEMS

Purpose	Cost: ¢/1000 gal.
Support services	9.0
Acquisition	6.7
Treatment	3.5
Power and pumping	5.2
Transmission and distribution	4.4
Total	28.8

For the small sample of systems investigated, capital costs are about 30 percent of operating costs and treatment costs are only about 12 percent of total operating costs. Monitoring costs are usually included in the treatment costs.

The cost of complying with the new primary drinking water regulations and the proposed regulations for organic contaminants is not yet firmly estimated. A study in response to Section 1442(a)(3)(B) of the Safe Drinking Water Act is currently underway which should provide some useful estimates. The best available estimate at this time places the capital costs of meeting the primary standards between $1.1 and $1.8 billion and annual operation and maintenance, including monitoring, at about $250 million (Energy Resources Co., 1975). Estimates for the use of GAC to meet the proposed regulations for organic contaminants vary from $831 million in a study prepared for EPA to industry estimates up to $5 billion (McDermott, 1978). The main difference between the estimates is in the number of locations requiring the GAC treatment, but differences also exist in design criteria and cost assumptions.

It is clear that the smaller systems will pay relatively higher costs for GAC than the larger systems. Treatment costs for a system serving a population of one million will be approximately half that of a system serving only 100,000 people (Temple, Barker and Sloane, 1978). Especially for the very small plants serving less than one mgd (population of 5 to 10,000) cost of on-site carbon regeneration would be especially high if GAC treatment was found to be needed in the future. The availability of a central processing facility could help to reduce this cost. While GAC may ultimately be required for a number of systems threatened with significant contamination by synthetic organics in the raw water, reduction of trihalomethanes alone may be accomplished at a lower cost in some systems through the use of alternative disinfectants and/or modifications to the sequence of treatment operations.

Another consideration in the financial ability of water utilities to deliver an adequate and dependable supply is the cost associated with maintaining, repairing or replacing large facilities as they reach or surpass their usable life. Many water systems, particularly the large systems in older metropolitan areas, have average ages of 75 to 100 years as shown in Table VI-3 (adapted from Temple, Barker and Sloane, 1977).

Table VI-3

AVERAGE AGE OF WATER SYSTEMS IN 1976 (BY POPULATION SIZE)

	25-99	100-499	500-999	1,000-2,499	2,500-4,999	5,000-9,999	10,000-99,999	100,000-999,999	1 million
Average Age (years)									
Public	30	30	36	42	48	48	62	77	100
Private	18	21	20	25	40	22	75	97	72
All	18	24	32	38	47	46	64	81	95

In some cases, facilities such as primary transmission conduits, major storage, or treatment facilities, may require significant improvements or replacement, at very large cost.

2. Financing Water Systems

Water supply is a capital intensive enterprise; water systems, both public and private, depend heavily on long-term debt to fund their capital needs. Long-term debt represents from one-third to one-half of the assets of most systems. Traditionally, public water systems have been financed at the local level. As of 1971 it was estimated that 83 percent of total expenditures had been made by local and state governments, 10 percent by private sources and 7 percent by the Federal government (National Water Commission, 1973). Public water supply systems rely most frequently on the use of bonds to finance capital expenditures and depend on revenue from water sales to meet operating costs. Some systems pay small amounts in lieu of taxes into the municipal treasury and some rely on ad valorem taxes to meet part of their operating expenses. Privately owned water systems also issue bonds to fund capital expense, but may also use stock sales or retained earnings. Both cost of capital and operating expenses must be met by revenue from water sales or the utility will operate at a loss.

Although most capital costs and all operating expenses must be financed and recovered by the individual utility, some assistance in capital funding is available through Federal or State Programs. These are briefly summarized in the following subsections.

a. Federal Financing

- Farmers Home Administration (FmHA). The FmHA can make grants or loans to communities of less than 10,000 people, with priority given to rural communities with less than 5,500 population, to cover up to 75 percent of the cost of renovating an existing water system or building a new one.

- Soil Conservation Service (SCS). In conjunction with its program for small flood control reservoirs, the SCS may provide assistance for storage of municipal water, but not for transmission, treatment or distribution.

- Corps of Engineers. The Corps is authorized to include storage for municipal water supply in its multipurpose reservoirs. The municipality is expected to repay its share of the cost of these facilities.

- Economic Development Administration (EDA). The EDA can provide grants up to 50 percent of project cost to assist economically depressed areas in improving their situation.

- Bureau of Reclamation. The Bureau is authorized to provide loans to irrigation districts for projects which may include municipal water supply. Projects must have been authorized and be located in the 17 western states. Up to 10 percent of project costs must be contributed by the grantee and water supply costs must be repaid with interest.

- Small Business Administration (SBA). The SBA can provide loan guarantees for privately-owned water systems if regular commercial lending sources will not provide funds.

b. State Financing Sources

Seventeen states have programs which provide financial assistance for water supply. These programs range from assistance in construction costs to upgrading of water treatment facilities to planning with funding provided via grants or loans. Table VI-4 summarizes the state programs that existed as of July 1978 (EPA, 1978).

B. Wastewater Management

1. Costs

The costs involved in wastewater management are broad-ranging, from collection, treatment and disposal or reuse of municipal and industrial point source discharges to structural controls and management practices for nonpoint source discharges. This section focuses principally on the costs associated with municipal wastewater.

Typical costs for municipal wastewater collection and treatment taken from recent surveys (Dames and Moore 1978a, 1978b) are presented in Table VI-5. The data have been arranged in terms of cents per

Table VI-4

STATE PROGRAMS FOR FINANCIAL ASSISTANCE

TO MUNICIPAL WATER SUPPLY

<u>Region I</u>

Massachusetts	Grants for 30% of total eligible construction costs; Grants for 30% of annual principal payment for treatment facilities
Vermont	Matches local contribution with grants

<u>Region II</u>

None in Region

<u>Region III</u>

Pennsylvania	Grants of up to 75% or $75,000 to systems with less than 12,000 population for planning; Grants of up to 50% of project cost

<u>Region IV</u>

Georgia	Grants of up to $150,000 for upgrading of publically-owned water systems
North Carolina	$110 million appropriation for water supply grants
South Carolina	$200,000 annual allocation to small communities for matching Federal funds
Tennessee	100% loans for construction and expansion

<u>Region V</u>

Indiana	Loans of up to $150,000 over 20-year period to communities with 1,250
Ohio	Loans of up to $500,000 for water supply improvements to communities 5,000

(continued)

Region VI

Texas	100% of project cost loans

Region VII

Missouri	Grants to upgrade only water systems improvements not necessary to satisfy primary requirements

Region VIII

North Dakota	Loans to rural water districts with FmHA funding to meet cash flow
Wyoming	Loans and grants for water systems

Region IX

California	Loans of up to 100% of project cost

Region X

Alaska	Grants of 50% of eligible cost or 50% of eligible cost not Federally financed
Oregon	Loans for water storage, irrigation pumps, and secondary M&I water
Washington	Loans for 100% of planning and engineering; grants for 40% of eligible construction costs

Source: EPA (1978)

Table VI-5

AVERAGE COST OF WASTEWATER COLLECTION AND TREATMENT
(cents/1000 gallons)

Level of Treatment	Population Served			
	8,000-40,000	40,000-150,000	>150,000	All plants
Operating Costs				
Treatment				
Primary	17.6	13.7	4.7	15.9
Secondary				
Trickling filter	21.2	16.2	9.5	19.6
Activated sludge	31.6	16.5	14.9	26.8
Advanced	45.4	25.1	13.6	39.8
Collection[a]	-	-	-	14.5
Capital Costs[b]				
Secondary treatment	56.8	46.4	41.9	-
Greater than secondary treatment	86.5	82.5	-	-
Upgrade primary to secondary	32.7	32.4	32.2	-
Upgrade secondary to advanced	22.2	19.2	17.4	-

a. Average of all collection system and pumping O&M costs for systems with separate sewers and treatment facilities.
b. Includes construction plus all non-construction costs amortized at 6-5/8%, 20 years.

Source: Dames and Moore (1978a, 1978b)

thousand gallons for various service population categories in order to draw some comparisons with the data previously presented for water supply costs. Economies of scale are also evident in this situation. Operation and maintenance costs appear similar for both water supply and wastewater management, particularly when the level of treatment is secondary or advanced. Total capital or construction costs appear significantly higher for wastewater treatment, if compared to the typical interest expense borne by water supply utilities as a measure of capital financing. However, the fact that nearly all of the municipal wastewater treatment costs are eligible for Federal and often state funding, means that the actual share assumed by the local wastewater agency is only one-fourth or less of that shown in Table VI-5.

The 1978 EPA Needs Survey (EPA, 1979a) estimates a capital cost of $125 billion to bring national wastewater disposal facilities up to requirements for 1977, with an additional $42 billion needed to meet expanded requirements by the year 2000. The latter costs, detailed in Table IV-6, are for meeting 1983 interim goals of the Clean Water Act and do not include the cost of eliminating the discharge of pollutants, the target for 1985.

More than one-third of the costs in Table VI-6 are for stormwater control, a major component of nonpoint source pollution. No comparable estimates are available for control of other components of nonpoint pollution discussed in Chapter IV. The total national cost for control of nonpoint source pollution will be large but requires further study. A comprehensive inventory will be required before the net cost can be estimated. Alternates to chemical pesticides could ultimately provide effective pest control at no greater cost than at present and simultaneously eliminate a source of pollutants. Management practices which control erosion also help to control washoff of chemicals.

2. Financing Wastewater Treatment Systems

a. Federal Financing

The EPA Construction Grants Program for POTWs has been discussed briefly in Chapters II and IV. As of February 28, 1979, a total

Table VI-6

WASTEWATER FACILITIES NEEDS

FOR YEAR 2000
(billions $)

Needs Category	Year 2000 EPA Assessment	Backlog Estimate
I (Secondary Treatment)	15.09	9.66
II (More Stringent Treatment)		
A. Secondary Levels	(11.0)	
B. Advanced Secondary	(6.8)	
C. Advanced Treatment	(2.7)	
Total Category II	20.51	10.63
IIIA (Infiltration/Inflow)	2.44	2.44
IIIB (Replacement and/or Rehab.)	4.88	4.87
IVA (New Collector Sewers)	19.02	19.02
IVB (New Interceptor Sewers)	18.47	6.69
V (Combined Sewer Overflow)	25.74	25.74
Total I, II, IVB	54.07	26.98
Total I-V	106.15	79.05
VI (Control of Stormwater)	61.67	45.70
Total I-VI	167.82	124.75

Source: EPA (1979a)

of $20.8 billion had been obligated for construction since enactment of PL 92-500, with $19.0 billion of this total representing grants still active as of March 9, 1979. Of the total obligations, approximately equal amounts of about $670 million were obligated to Step 1 Planning and Step 2 Design, respectively, with the remaining $19.3 billion obligated for actual facilities construction (Step 3).

Grants under section 201 are made directly to the local implementing agency, and in most states the EPA region is the primary review and approval agency. However, as of March 1979, eleven states had been delegated grant review and approval authority under Section 205 of the Act.

The regulations governing the Construction Grants Program are lengthy and complex. Basically, however, the grants are for facilities to meet water pollution control objectives; project features which serve other purposes are not eligible for grants. For example, a pipeline conveying effluent to a point of use for irrigation is eligible only if the irrigation is viewed as a land treatment process used in lieu of conventional treatment required prior to discharge, and the overall project in the most cost-effective solution. The cost-effective guidelines provide a 15 percent "bonus" for innovative and alternative processes such as reuse through land treatment. Multi-purpose projects are encouraged; i.e., agricultural or industrial reuse, groundwater recharge, energy recovery, urban drainage, recreation or land reclamation. Presently in such multi-purpose projects, the portion of cost eligible for grant funding is determined on a case-by-case basis based largely on the least costly conventional pollution control option. Funding of multiple purpose projects has been under study by an EPA task force since November, 1978.

In addition to EPA, the Farmers Home Administration of the Department of Agriculture makes grants up to 75 percent and loans for the construction of wastewater collection and treatment systems in rural areas; highest priority is given to projects in rural communities of less than 5,500 population and no part of a city with a population in excess of 10,000 can be included. The Department of Housing and Urban

Development (HUD) makes grants to cities for sanitary sewer systems but not for treatment works; it can provide financial assistance for treatment works to a nonprofit corporation to serve a population of less than 10,000 if there is no public body to construct and operate the works.

b. State Financing

Thirty two of the states assist the local municipalities in raising the 15 to 25 percent share (i.e. depending on whether the alternative qualifies for bonus funding in which case the lower percentage would prevail) to combine with the Federal assistance. This assistance may be in the form of grants or loans. A summary of the relative percentages of state assistance available is provided in Table VI-7.

C. Energy Considerations

In water supply systems, energy is used primarily for pumping in one or more of the following functions: pumping groundwater; pumping water from a surface supply; pumping water through the treatment plant; pumping water through the distribution system. Wherever feasible the engineer designing a water supply system will use gravity for moving water. Thus in a few cases no pumping is required, but these are the topographically favored surface water systems with water available at a sufficiently high elevation so that water can be fed by gravity throughout the system. On the other hand most systems relying on groundwater require energy for delivery to and distribution within the service area as well as pumping from the well.

Conventional water treatment methods do not usually require large amounts of energy for process operations although various mechanical devices in the usual treatment plant are motor driven. A major energy related cost in water treatment is chemical cost. Use of large quantities of lime, alum, etc. (especially if lime sludge is recalcined) entails a significant expense. Carbon production and regeneration are also energy intensive.

A special case of large energy consumption is encountered when the water is high in dissolved salts and reverse osmosis or electrodialysis is employed to desalt it. In this case it may be desirable to desalt

Table VI-7

STATE PROGRAMS FOR FINANCIAL ASSISTANCE
TO MUNICIPAL WASTEWATER FACILITIES

Region I

Connecticut	15%
Maine	15%
Massachusetts	15%
New Hampshire	20%
Rhode Island	15%
Vermont	15%

Region II

New Jersey	8%
New York	12.5%
Puerto Rico	25% [2]
Virgin Islands	25% [2]

Region III

Delaware	10%
Maryland	12.5%
Pennsylvania	12.5% of eligible Step 1
Virginia	Hardship grants up to 15%
West Virginia	5-15% plus Step 1 and 2 funding
District of Columbia	25% [2]

Region IV

Georgia	Up to $150,000 for upgrading
N. Carolina	12.5%
Tennessee	25%

Region V

Illinois - has own program of 75% grant

Indiana	10%
Michigan	5%
Minnesota	15%

Wisconsin - has own program of 60% grants

Region VI

New Mexico	12.5%

Region VIII

Iowa	5%
Missouri	12.5%
Nebraska	12.5%

Region VIII

None in region

Region IX

California	12.5%
Hawaii	10%
Amer. Samoa	25% [2]
Tr. Terr. of Pac. Isld.	25% [2]
Guam	25% [2]

Region X

Alaska	up to 50% [3]
Idaho	15%
Washington	15%

1) May decrease due to lack of funds
2) Applicant same as state
3) Lesser of 50% of eligible cost or 50% of eligible cost not financed by Federal government

Source: EPA (1979b)

only water used for drinking and cooking by providing a three pipe system in the house -- hot, cold, and desalted. It has been argued that population growth in such areas should be limited to that necessary to carry on those functions which can only be performed at the location.

Whenever possible, a wastewater treatment plant and final disposal are located such that the collecting sewers can deliver sewage to these facilities by gravity. Frequently, however, topography does not permit such an arrangement, and energy for pumping is required in the collection system, at the treatment plant, and occasionally prior to final disposal. Wastewater treatment, on the other hand, can be significantly more energy intensive than water treatment, particularly in the activated sludge process and many advanced treatment processes. Water conservation and optimal design of the facilities are most likely to be effective in energy conservation. Occasionally, delivery of treated wastewater for reuse may involve pumping long distances and over significant elevations. Careful siting of the treatment facility offers the greatest opportunity for energy saving in this case, if a new facility is to be provided.

D. Opportunities and Problems

Given the preceding background in cost and energy implications, several opportunities and problems emerge in terms of coordination between water supply and wastewater plans, and water supply availability.

1. Coordination Opportunities

In some cases, coordination between planning for water supply systems and wastewater management facilities can or has achieved sigficant savings in cost and/or energy. The following presents some examples of possible cost or energy benefits from coordination:

- When multiple agencies utilize a water basin - either surface or groundwater - for both water supply and wastewater disposal, close coordination can be important in terms of achieving cost effective solutions. This can apply to the location of sites for water supply intakes and wastewater outfalls, or to the planning of required treatment for either purpose. A recent EPA study (Culp, Wesner, Culp, 1978) provides insight into some of the considerations involved for surface water planning, and suggests, for example, that in some cases it may be more cost-effective to provide additional water treatment rather than advanced wastewater treatment.

- Because of scale economies consolidated wastewater treatment may be a cost efficient alternative to many small treatment plants. On the other hand, if the effluent were to be reused for any purpose, smaller dispersed plants might be the most efficient because of reduced pumping and pipeline costs from a plant to point of use.

- Conservation of water can delay the need for new investment in water supply and wastewater treatment. Reduced water use means less wastewater per capita and a potential saving in capital and operating costs as well as energy. Coordinated planning can help realize such savings.

- In some cases, conservation of the resource might be achieved through reuse and water rights exchange. If, for example, higher quality water was rescued for municipal use, with returned wastewater guaranteed for agricultural use, a savings in total withdrawal is achieved, and potentially a significant reduction in the cost of developing an additional domestic supply source or condemning agricultural rights.

2. Coordination Constraints

The above are only a few examples demonstrating the potential cost or energy savings of coordination between water supply and wastewater system planning -- values which have been realized on occasion in the past and should be available in the future. Coordination is not, however, without constraints. Commonly the planners are working as two separate groups and may not even be aware that they are working on situations which intersect until a "final" plan is released by one group. Many times it will be found that planning for only one function is underway and thus wastewater planning would have nothing with which to interact. In other cases coordination of water supply and wastewater planning could be enhanced through the use of a common set of population and land use projections but the municipality's land use plan is nonexistent, out of date, or developed without due regard for the water supply situation or wastewater facilities requirements and thus not very realistic. A related problem is that the municipality may have failed to capture the economic benefits of a comprehensive community conservation strategy (e.g. to conserve water, reduce per capita wastewater flows, decrease energy requirements, guard against "leap frog" development and protect prime agricultural lands) because land use and growth plans have not integrated water and wastewater systems plans.

Funding mechanisms may also lack sufficient incentives to encourage effective coordination. For example, if grant funds are not available for relocation of a water intake, which would avoid a more costly wastewater treatment and discharge alternative, there is little incentive to make the wastewater planners willing to consider this alternative. Similarly, the cost of irrigation water may not be such as to encourage an irrigator to consider reclaimed water at relatively high cost coupled with the attendant possibility of a liability claim because of his use of reclaimed water. The point is that exploration of alternatives in planning is not free. Each alternative requires time for evaluation and possibly some field investigation to provide facts. If planning organizations are inadequately funded they will be reluctant to explore alternatives which offer their function little or no advantages.

Constraints such as those cited above may not be valid reasons for not obtaining effective coordination since most of them could be eliminated by more flexibility in planning and financing water supply and wastewater systems, and in providing incentives for a comprehensive conservation strategy. However it must also be recognized that opportunity for coordination does not occur in every planning situation, i.e. in many cases there is no impact between wastewater and water supply, perhaps because water supply is from groundwater or if from a surface stream, there are no wastewater sources upstream. Hence, a blanket requirement for coordination may not be a useful solution.

3. <u>Water Supply Availability</u>

Water supply systems can experience a variety of financial problems but an overall review of the current situation suggests that there are several major ones which dominate. These are the problems of the small water utility, the problems of aging water supply systems, and the costs of controlling organics in drinking water.

It has been noted that small systems generally suffer from the problems of scale economies. On the average, capital and operating costs are two to three times greater for the small system than for the large systems. Averages tend to hide the exceptions, however, and each system is unique in its physical and economic setting. Some small systems, such as small groundwater systems, have a large source of pure water and a compact service area such that costs are quite low. On the other hand, some small systems may find the only easily accessible source of water is too saline for use without relatively costly treatment. Some small water services operate without any paid staff and, hence, have little available manpower and generally no available technical skills. Deficiencies in either quantity or quality of water delivered by small systems is frequently linked to either inadequate capital or operation and maintenance funding.

As also mentioned, many water supply systems, particularly the large urban and metropolitan systems, are quite old. Major components of such systems may be in need of rehabilitation or replacement. The costs for this work may be far more than that of maintenance and repair required under normal circumstances. Under the present financing structure, subsidy mechanisms for needed improvements are limited, and the bulk of financing capital costs would be borne by the individual utility and, ultimately the customers. This problem has been recognized by the Intergovernmental Water Policv Task Force. A Subcommittee on Urban Water Supply, under the leadership of the Secretary of the Army, is undertaking a study to evaluate existing assistance programs, institutional and financial problems, and propose policy or program changes. The task force report is expected to be completed in late 1979.

The cost of controlling organics in finished drinking water will undoubtedly prove quite expensive for some utilities. There is still debate about proposed regulations for GAC Treatment, and unresolved questions remain regarding the extent of the systems ultimately involved, the most cost-effective method of control for THM's and/or synthetic organics for any given water system, and the degree of regulations/requirements that are necessary. For the systems for which additional control procedures are necessary, however, the increased capital and operating costs may be very significant and will be passed on to the consumer.

E. Summary/Findings

The preceeding discussion of cost and energy considerations leads to the following findings:

- Capital costs for wastewater facilities tend to be greater than water supply facilities on a per gallon basis. However, Federal and State funding programs significantly reduce the local economic impact of wastewater facilities construction.

- Operation and maintenance costs are similar for water supply and wastewater management on a per gallon basis, and on the average show definite economies of scale.

- Wastewater facilities funding needs to meet the goals of the Clean Water Act are two orders of magnitude greater than the estimated water treatment needs to meet the Interim Primary Drinking Water regulations.

- A variety of potential opportunities, as well as constraints, exist for arriving at cost-effective and coordinated solutions to meet wastewater and water supply needs. These are, however, dependent on local and State characteristics such as institutional arrangements, legal structure, physical features, and social values.

  There are several potential cost-related problems facing the national ability to deliver adequate and dependable safe drinking water supplies. These include the financial capabilities of the numerous small water supply systems, rehabilitation/replacement needs of aging urban water systems, and the ultimate cost impacts on water supply systems needing significant modifications to control organic contaminants. The problems of rural water supply systems are being addressed in a Rural Water Survey in response to Section 3 of the Safe Drinking Water Act; however information is lacking on the needs of small community systems. Similarly, studies are underway on the cost of controlling organic contaminants and on needs for rehabilitation of large urban systems.

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Chapter VII

PUBLIC PARTICIPATION IN SELECTING PRIORITIES

A. Introduction

Answers to the questions posed by Congress which this study is addressing could have far reaching effects on factors that weigh heavily in the political decision making process--equity, change in balance of power, impact on present and future quality of life to name a few. By necessity, then, the initial scope of work called for an approach that was part technical and analytical, and part nontechnical and investigative. The analytical portion of the study is documented in other chapters of the report; this chapter reports on findings that emerged from investigating what concerns people have about "adequate and dependable supplies of safe drinking water" and a requirement for "coordination between water supply and wastewater control plans as a condition to grants...".

B. Regional Workshops: Involving the Public in the Study Process

1. Preparation/Dissemination of Discussion Paper

Recognizing the value of having a background document to help the public enter into the study process as soon as possible, the contractors' efforts during the first two months of this study concentrated on an exploratory analysis of issues/questions surrounding various aspects of the questions raised by Congress, and preparation of a discussion paper based on that cursory review of available data. Concurrent with this, the Office of Regional and Inter-governmental Operations (ORIO) in EPA headquarters coordinated with the Regions to develop a list of possible participants in public workshops, to invite these persons to attend, and to provide the contractor with a mailing list for the background discussion paper. The dates and locations of these workshops were also published in the Federal Register and requests for the paper generated as a result of this announcement were added to the mailing list. In all about 2,000 papers were distributed during the first week of January and at the workshops. Dates and locations of the workshops are as follows:

- San Francisco -- January 17 and 18
- Dallas -- January 24 and 25
- Atlanta -- January 31 and February 1
- New York City -- February 7 and 8
- Chicago -- February 14 and 15

2. Structuring the Workshop Format

The EPA Task Force and the contractor agreed that every attempt should be made to provide an open atmosphere in the workshops where people would feel free to express their views. Thus the contractor had a lead role with responsibility for preparing the presentations, providing workshop leaders, surveying proceedings during plenary and small group sessions, and synthesizing and analyzing public input. On the other hand, EPA played a key role by arranging facilities, and providing workshop moderators and small group facilitators. Finally, participants played both lead and support roles by serving on panels, speaking out in plenary and small group sessions, acting as recorders for the small group discussions and reporting their findings at the end of the day in plenary session, and expressing "minority views" in the event that a small group did not arrive at consensus regarding its conclusions and recommendations.

3. Data Collection and Synthesis

Data gathering by the contractor took the form of tape recording at the plenary sessions, note taking at these sessions, attendance and note taking in as many small groups as possible, discussion with individual participants, collection of recorder's notes, and request for and collection of memos from the workshop leaders and small group leaders. In addition written comments from participants were invited.

All raw data described above was transcribed and typed, organized in regional notebooks, and synthesized and analyzed by the contractor. Copies of these working documents were forwarded to EPA Headquarters and the respective host Regions. A national summary and analysis which contained as appendices the regional summaries/analyses from the notebooks was also prepared by the contractor and forwarded to Headquarters.

4. Coordinating Public Views with Study Team Efforts

The initial analytical phase--i.e. discussion paper--as well as the investigative phase--i.e. public workshops--indicated that a myriad of technical, legal, institutional and social issues arise when considering water use, availability, safety, quality, funding, regulation and responsibility. This was hardly a surprise. However, the task for the study team following the workshops was to decide on priority issues for further analysis, present these issues to the Task Force for modification and/or concurrence, and develop a detailed work plan for addressing them. Thus the following criteria were established for screening the many issues/questions that could be analyzed in order to arrive at a set of priorities:

- The topic is of significant concern to the public as evidenced by the workshop response.
- It is within the specific scope of the study: (1) adequacy and dependability of safe drinking water supplies; (2) municipal water supply and wastewater management coordination.
- It is complementary with rather than duplicative of other ongoing studies and reports.
- It may be local in nature but because of its widespread occurrence or its magnitude it is of national significance.

As indicated by the above, the public workshop results had a direct influence on the course of this study by assisting the contractor and the Task Force to arrive at a focus for analysis and by serving as a touchstone for the study team to use in melding the less tangible and nontechnical aspects of the issues with the more quantifiable and technical considerations.

C. Public Views: Highlights and Observations

The workshops were well attended despite poor weather conditions with the ratio of participation to invitation running about one in three. Participants came from 43 states, from Puerto Rico and from Canada. Approximately 11 percent of the participants were affiliated with Federal agencies, 20 percent with State agencies, 23 percent with local agencies or utilities, 12 percent with industry and 12 percent with special interest groups, 10 percent with Regional Councils or Commissions, 5 percent with universities and the remainder either unidentified or registered as individual citizens. Although as previously noted the participants spoke to numerous subjects, the following presents a composite of that discussion in particular as it relates to priority topics raised in the wording of 1442(c) and 516(e). Where appropriate, regional views are indicated.

1. Adequacy and Dependability of Water Supplies for Domestic Use

There was widespread and strong support for continuing to entrust responsibility for the adequacy and dependability of municipal water supply to the local level, even though there was widespread agreement that domestic water supply problems are prevalent and that these are hidden in national data. It was felt that, in general, the water utilities whether publically or investor owned have exhibited a trustworthiness in terms of providing sufficient supplies and that no new wholesale Federal program is needed or wanted. There were exceptions to this general sentiment, however, which must be noted.

Of concern was the plight of small community or rural systems. Putting the safety or quality issue aside for the moment, there was a prevailing attitude that small systems may already have problems with adequacy and dependability due, for example, to heavy reliance on wells and lack of financial ability to go deeper for water in the event of drought or other factors which lower the groundwater table. Rural communities were not well represented in the workshops, however, and it was not possible to extract the full dimensions of this problem although several public health officials who work in rural areas expressed significant concern. There was also not concurrence on what should be done to assist small systems. Suggestions ranged from direct financial aid in hardship cases to low cost loans to market rate loans. Neither was it clear who should be responsible for administering assistance programs although there was considerable support for allocating such responsibility through existing agency programs such as those under the purview of the FmHA, EDA and HUD. There was in general not a clear understanding of what type of assistance these agencies provide or how the assistance relates to the adequacy and dependability question.

A second exception to the general attitude of leaving municipal supply responsibility at the local level surfaced in the New York workshop. Here there was concern expressed about rehabilitating and/or reconstructing antiquated urban water systems in the Northeast. Related recommendations were to include "drinkable" along with "fishable and swimmable" in the 1983 goal of the Clean Water Act, to redirect funds from existing programs presumably including the 201 facilities program to system rehabilitation, and to provide low cost loans to be repaid by users. It should be noted that there was opposition expressed to this viewpoint by those who believe that users should be responsible for maintaining a system and paying the maintenance costs. On the other hand there was a rather broad concern that quantity problems exist in the water-rich Northeast in contrast to the semi-arid Western States and that problems unique to this region are seldom brought to the attention of Congress.

Finally in the Dallas workshop it was noted that in order to assure an adequate and dependable supply of water for all uses it is necessary to anticipate needs and develop water resources to meet those needs in water-short areas like Texas. A spokesperson for Arkansas further noted that in water-rich areas there is a need to develop distribution systems to get water to the people which may require Federal assistance.

2. Safety of Drinking Water Supplies

The question of safety frequently turned into discussion about the efficacy of Federal standards and treatment requirements rather than safety per se. In the Atlanta workshop, for example, spokespersons for utilities in one of the small groups strongly stated their position that Americans have the safest water in the world thanks to the water supply industry. In Dallas the proposed regulations for GAC were labeled as irresponsible and in San Francisco it was suggested that the Federal government should pay for implementing ridiculous Federal regulations. However a public health official in the Dallas workshop raised the question about why participants, given their affiliations, had any expertise to speak to the issue of health impacts. While the regulations are being studied by other on-going efforts, and research is continuing on health effects of constituents in drinking water supplies, the vehemency of comments made warrants mention in this report.

Of direct interest to this study, however, are two topics which came up in all workshops: safety of supplies in small systems and source protection. Regarding small systems public health officials in the Atlanta workshop noted that rural residents frequently suffer health effects due to polluted domestic supplies, and in the San Francisco workshop a State official observed that small systems in parks and recreation areas are inadequately treated due to lack of personnel and funding. Others observed that all Americans deserve to have safe supplies. A minority view expressed in the Dallas workshop was that people in rural areas should be willing to pay for adequate treatment or move to the cities where users do pay for safe drinking water supplies.

Similar to the adequacy and dependability subject there was not a consensus on how the safety of small system supplies can or should be assured. For example suggestions in the New York workshop ranged from direct Federal assistance, assistance to the States for allocation on a priority basis, providing subsidies for regional labs to monitor and test water supplies, public education on waste disposal methods which protect individual supply sources, to beefing up existing Federal programs for technology transfer and technical assistance. A suggestion in the San Francisco workshop was to switch to bottled water.

The second major concern--source protection--related primarily to groundwater although persons in the New York workshop also mentioned surface supplies and watershed protection. The inadequacy of groundwater protection was raised in all workshops. In San Francisco, for example, it was observed that agricultural policies may be in conflict with groundwater protection due to dangers of intrusion of chemicals into the groundwater (or for that matter into surface supplies through nonpoint source runoff), that FmHA subsidies for water supply do not account for quality impacts and have resulted in systems that are now below standard, and that present sludge disposal policies may have adverse effects on groundwater. In Atlanta a similar concern was expressed over the impact of agricultural expansion and irrigation techniques on both quantity and quality of groundwater, and over the preference accorded to land treatment in the Clean Water Act which may contaminate this supply source.

While source protection in general, and groundwater source protection in particular appear to be a nationwide concern, the most acceptable mechanisms for protection are not readily apparent. In the Chicago workshop, for example, recommended mechanisms included enforcement/implementation of existing laws and programs such as: regulation of point source discharges of toxic and hazardous wastes under the Clean Water Act; implementation of Title III of the Water Resources Planning Act; reexamination of impact of land treatment on water supply; shifting of funds from Construction Grants to programs such as Rural Clean Water, Surface Mine Reclamation, and Toxic and Hazardous wastes. Some New York workshop recommendations were similar, but others included: increasing public awareness of the importance of protecting supply sources and mechanisms available to do so (e.g. land use planning to protect watersheds and aquifer recharge areas); requiring the polluter to pay to remove pollutants from supply sources; technical assistance from EPA and other Federal agencies, if requested, to the local level in order to assure more thorough consideration of source protection in local plans.

3. Conservation and Reuse

Notions about conservation vary from region to region as might be anticipated. While there was little disagreement that the concept of conservation as an ethic is a good one, there was widespread agreement that a mandatory Federal policy with national standards and regulations would not be acceptable. Little if any quantitative information was forthcoming in any of the workshops, although examples of conservation were set forth with the caveat that these came about as a result of special circumstances and economic incentives at the state/local level and not from Federal pressure. It was also observed that conservation frequently results in higher prices for water, so it is not clear what the economic incentives are. Energy savings were cited in the Chicago workshop, savings in terms of learning to live within the limits of an existing septic system was mentioned in Atlanta, and possible cost savings in wastewater treatment were noted in San Francisco and New York.

Neither was there universal agreement on a workable definition for conservation with a rather clear distinction between the semi-arid and water-rich regions. In San Francisco, for example, one group noted that a holistic view of conservation--e.g., energy requirements, crop production--needs to be taken in contrast to merely talking about conserving water. It was also observed in that workshop that conservation has reached its limit in many areas of the west and that mandatory measures could induce hardship--e.g. farmers have long known the value of water and have practiced conservation in the sense of preserving it for its highest use in terms of crop production. In the Dallas workshop one of the small groups came up with its own definition: "the wise and efficient development and use of the total water resource in light of present and future demand". It was also noted in that workshop that Texas has a metering policy which has proven to be an effective conservation mechanism.

As the workshops proceeded east, attitudes toward conservation changed although the notion that conservation policy is a state/local decision did not. In Atlanta it was deemed important for state water plans and policies to have conservation elements (Georgia has recently adopted a policy to require water conserving devices in new development). This would seem to imply a working definition slanted toward reduction in use.

If there was not broad consensus on the meaning of conservation neither did a distinctive conservation mechanism emerge. In New York recommendations from the various small groups included: a national plumbing code (with an implementation decision at the local level); contingency plans for conservation during drought; public education; adjustments to rate structures; metering. Opposing views were presented to two of these recommendations: installation of metering in New York City would be prohibitively expensive; rate structures should be associated with cost of service not level of use. In Chicago, some recommendations were similar to those in New York but others included: leak detection pilot programs; national policy that Federal agencies should not provide water for new development thereby promoting growth and increased water consumption.

Similar to conservation, reuse was viewed as a good concept but one that must be determined by location specific circumstances and needs. In San Francisco it was observed that the highest and best reuse might be discharge to the Bay to prevent salt water intrusion. It was also observed that care needs to be taken to avoid creating a new use, that further research is needed to identify the impacts of using treated wastewater on various types of crops and that treated wastewater is simply not cost competitive with groundwater or reservoir water. In Dallas it was noted that wastewater is already counted as part of water supply and thus Texas practices reuse. There was little substantive discussion of reuse in the other workshops.

4. Coordination as a Condition to Construction Grants

While there was little disagreement that coordination in and of itself is a good thing, and some surprise that it did not occur as a matter of course, the word "condition" raised the ire of most workshop participants. The opposition to any further requirements or conditions was vehement and at times stood in the way of identifying and discussing possible advantages. The depth of sentiment warrants a consolidation of comments on a region by region basis.

In San Francisco it was observed that there are numerous vehicles presently on the books which mandate or provide an opportunity for coordination; examples include the NEPA process and the A-95 review process. It was further noted that local coordination does take place when there is a need for it, but that coordination at the top is not nearly so apparent. Numerous needs for improved coordination were mentioned including: between Federal research and development and local decision making requirements; among various agencies using different population, density and land use projections; within 208 planning but with the caveat that a national "cook book" approach to such planning is not feasible; between regional characteristics, including water use, and standards under the Clean Water Act and Safe Drinking Water Act. One positive recommendation for local implementation was development of a system by which wastewater treatment would be billed in proportion to the amount of water used and both charges would appear on one invoice.

In Dallas a coordination requirement was opposed because it presumes that there is no local and state level coordination which is not the case; any additional requirements for a construction grant will possibly halt construction or cause further delays in meeting the Congressional goal for abatement of pollution; conditions are tantamount to control and the Federal government already has too much control over local affairs; EPA already has enough to do without getting involved in municipal water supply. Suggestions for moving toward achievement of more coordination included: evaluation of existing programs and processes for coordination before embarking on a new law/program; where it has not been achieved, implementation of coordination through the 208 process; encouraging/requiring water supply and wastewater planners to use a common data base with such data derived at the local level.

Atlanta echoed San Francisco and Dallas in observing that mechanisms exist for coordination and no new laws or programs are desired. It was noted however that processes such as 208 planning should be revised to include water supply, 209 planning should be implemented to obtain a comprehensive view of all functional planning, states should have primary responsibility for in-state coordination and for delegating such authority to substate levels, and the 208 review process should be accelerated so 201 planning will have something with which to coordinate. In contrast to adding more conditions to the Construction Grants process it was felt that it should be modified to provide more flexibility and to speed up implementation; an example of flexibility was to allow funding of a water supply component of a least-costly wastewater treatment plan. Participants were also highly favorable to requiring use of a common data base although there was no consensus on who should choose that base.

In New York, the working groups developed some rather specific recommendations for coordinating water supply and wastewater planning including: coordinating goals and budgets under the Clean Water Act and the Safe Drinking Water Act with an eye toward economic efficiency; further enforcement of NPDES permits in view of water supply concerns; modify the Construction Grants Program to ensure adequate review of water supply concerns prior to funding; reallocate existing funds under the Safe Drinking Water and Clean Water Acts to include funding for coordinated planning and sufficient funding of Federal agencies to allow them to provide technical assistance to local planning efforts; require coordination of water supply projections with wastewater treatment projections. It was also noted that 201 funding is oriented to engineering approaches when nonstructural solutions might be less costly and of more overall benefit. One example given was that of combining a low flow augmentation plan for in-stream water quality with a plan to allow natural processes of dilution of wastewater.

Chicago followed the trend of other workshops with recommendations for no new coordination requirements tacked on to the 201 grant process, fuller implementation of existing laws/programs such as increased funding to states for 209 planning and a strengthened Water Resources Council, modifying the 208 process to require consideration of water supply issues, and using State-EPA Agreements as a vehicle for coordination.

It should be noted that most of the participants felt rather strongly that Federal agencies need to coordinate both among themselves and with local plans/policies (where population growth is considered to be a local policy issue) and further that EPA programs need to be better coordinated. In fairness it should be noted that participation data indicate that there was not a large representation from the Federal government and thus recent attempts at coordination such as those initiated in response to the White House Initiatives of July 6, 1978 were never raised.

D. Summary/Findings

The following summarizes key findings that emerged as a result of public input to this study during the public workshops and in subsequent correspondence to EPA and the contractor:

- There is strong and widespread sentiment against any new Federal legislation and programs, and any significant increase in Federal involvement related to municipal water supply. Workshop participants across the country pointed out that Federal involvement generally results in laws and programs which ignore very real differences that exist within various regions, prescriptive regulations and standards that inhibit local solutions to local problems, and "cook book" procedures that are inefficient and inflationary.

- Despite the above, there appears to be considerable concern over adequacy, dependability and safety of small water supply systems--community, rural, and park and recreation systems. There is not consensus on what should be done but there is general agreement that some action should be taken in cases of critical need and that any such action should take place within the existing institutional/legal framework.

- There is a marked difference between eastern and western attitudes on priorities in Federal spending and policy regarding water supply and water quality: participants from eastern states suggested that there is a need for Federal assistance to rehabilitate antiquated municipal systems and that funds from existing programs should be redirected to this need; participants from western states did not raise this issue and input suggests that the attitude there is that appropriations for Federally authorized water quality funding should be ensured as outlined in the Clean Water Act.

- Source protection, in particular as it relates to groundwater sources, is a major concern. Strengthening existing programs and implementing legislation already on the books are seen as imperative to providing adequate protection of these supply sources. Provision of technical assistance, when requested, to the local/state levels is also viewed as important.

- As an ethic, conservation is widely supported; however a blanket Federal conservation policy or program that ignores regional and local differences is not and it appears likely that any such attempt would run into strong opposition. Comment on reuse suggests that it comes about when there is an economic incentive and when location-specific circumstances warrant it. However, similar to conservation, reuse is not seen as appropriate on a nationwide basis.

- The opposition to any additional requirements tacked on as a condition to section 201 funding of publicly owned treatment works is vehement. Not only is the existing construction grants process considered by some to be overburdened with requirements but also any additional requirements are seen to be inflationary, counterproductive to Congressional goals and timeframes for achieving desired in-stream water quality, and redundant since mechanisms for coordinating water supply and water quality planning are provided in present programs and procedures such as NEPA requirements, A-95 review process, and section 209 planning. Furthermore it is believed that coordination can and does come about at the local level as a result of voluntary institutional arrangements and need, and that coordination needs to start at the top of the governmental hierarchy rather than the other way around.

E. Focusing the Study

Results of both the technical analysis and the investigation of public views were presented to the EPA Task Force who had to decide on an appropriate focus for further in-depth analysis. It was recognized that considerable work would be required to develop results that would be substantive, meaningful for option formulation and decision making, and attainable within the time constraints imposed. Thus the criteria presented in Section B.4 of this chapter were used to screen through problems and opportunities identified in the exploratory phase of the study in order to pinpoint those that appeared to warrant priority in subsequent analysis efforts. The following subsections discuss the issues selected, the rationale for their selection, and the reason why some issues though important were not considered further.

1. Coordination Through Major Existing Federal Programs

Clearly the Congress has requested EPA to develop recommendations on a requirement to coordinate water supply and water quality planning as a condition to grants under section 201 of the Clean Water Act. Moreover, in line with the criteria, this issue was selected for further analysis for the following reasons:

- Coordinated planning could result in benefits such as implementation of a municipal conservation program through mechanisms like single billing for water and wastewater, protecting drinking water sources by including this objective in facilities siting and treatment technology decisions, or designing a waste treatment facility with a design capacity that is in balance with the available water supply.

- While any benefits of coordination appear to be highly dependent on local characteristics and values, the aggregate benefit to the Nation of encouraging such coordination could be significant.

- Although the public is vehemently opposed to additional conditions to 201 funding, there is a strong sentiment that existing programs could be used to encourage coordination when it would result in tangible benefits at the local level.

- Closer coordination of Federal programs with local goals and needs, as well as with physical and economic characteristics, is a nationwide concern.

- As a result of section 208 planning efforts, local institutions have been involved in water quality and to a far more limited extent in water quantity planning. Section 201 planning could be modified to address water supply in a search for overall water management plans that are cost efficient. Section 209 river basin planning is another vehicle for coordinated planning. Thus it appears that there are mechanisms within the existing institutional framework that could be used to encourage coordination.

2. Municipal Conservation and Reuse

Municipal conservation and reuse are an explicit concern in section 1442(c) and implicit in 516(e). In addition:

- Reducing the amount or at least the rate of growth in per capita municipal water use, and applying municipal wastewater to nonpotable uses, are attractive in theory but quite dependent on local characteristics in practice as noted in the public workshops. In addition, municipal water use is a small percentage of the total and there is no consensus on what the national benefits of municipal conservation are.

- Conservation and reuse have many potential benefits: e.g., lessen intensive competition for water among the various users; keep demand within the safe yield of a groundwater supply source or the capacity of a supply system; release agricultural or industrial supplies by substituting municipal effluents to serve those needs; leave more water in streams for in-stream uses; make more efficient use of resources by recycling nutrients; overall energy savings to consumers. The costs associated with achieving such benefits are less well understood.

- Nationwide conservation and/or reuse policies and standards are not viable options in the eyes of the public. Policies to encourage more efficient use of resources rather than to reward inefficient water supply and wastewater treatment systems would be more palatable.

3. Groundwater Management

Improvement of groundwater management to protect municipal water supply and water quality is relevant to both section 516(e) and 1442(c). In addition:

- Technical analysis and public workshop results suggest that problems such as overdrafting and contamination of groundwater sources are local and regional in nature but nationwide in scope.

- There is substantial information available from recent and on-going studies related to groundwater. While the state-of-the-art in measuring, monitoring and testing groundwater needs substantive improvement, there is sufficient information to study the relationship between safe drinking water supply and known or suspected groundwater problems.

- EPA has a number of programs related to groundwater protection. Thus a framework exists for encouraging improved groundwater management practices.

4. Small Water Supply Systems

Dependability and adequacy of municipal drinking water supply, an issue of 1442(c), appears to be more of a problem for small systems than for larger ones. It may require a more coordinated planning effort to assure safety of such supplies, a concern of both 1442(c) and 516(e). In addition:

- A large number of small systems have or could have financial problems in meeting Federal standards and regulations. In addition existing data suggests that although the problems are local in nature they are nationwide in distribution.

- Assistance programs are available to deal with some specific problems but a broader overview is desirable to examine methods for strengthening or coordinating such assistance.

- The public expressed concern over the plight of small systems but there was little agreement on what should be done.

5. Issues Not Selected

Findings from the assessment and the public workshop point to issues that were dropped from further consideration after screening them against the criteria. These include:

- Non-municipal conservation. In contrast to municipal use, other uses such as for agriculture are orders of magnitude larger and thus appear to have greater potential for conservation. However, non-municipal conservation is judged to be outside of the scope of this study in so far as in-depth analysis is concerned. In addition, many of the implementation Task Forces, established in response to the President's Water Policy Initiatives, are addressing aspects of non-municipal conservation.

- Rehabilitation of Antiquated Urban Systems. This issue is of considerable concern to the public, in particular in the east. As noted, however, it is being studied by an Intergovernmental Water Policy Task Force under the leadership of Secretary of Interior Cecil Andrus in response to the Presidential initiative. Thus it is not considered further in this study.

- Organics Control. EPA's proposed regulations for organics are a topic of public debate. Since the proposed regulations were first issued there have been many studies aimed at developing more substantive information on costs and benefits, and, as mentioned, there is some on-going work. Thus the issue is not considered further.

- Municipal Drought Supplies. There is little hard data that reflects the dependability of municipal supplies during drought. What information there is is largely local and it is not possible to extrapolate a national picture from it. As this study is required to use available data, this issue is dropped from further analysis, but with the recommendation that an adequate information base be developed.

Part 2: PRIORITY ANALYSIS

Chapter VIII

INVESTIGATION OF COORDINATION OPPORTUNITIES THROUGH MAJOR FEDERAL PROGRAMS

A. Introduction

As indicated in the assessment section, the present framework for addressing water-related problems is often one of distinct legal and institutional structures to deal with each of the areas of water quantity planning, water quality protection and pollution control, and the safety of drinking water supplies. Coordination in the broad sense is planning or implementing actions that integrate more than one of these areas to achieve an improved beneficial use of the resource. Numerous examples exist in which some degree of coordination is achieved. Nonetheless, conflicting goals and objectives, political and financial considerations, timing constraints, and other factors can and do create barriers to well-coordinated solutions in some situations.

The thrust of this chapter is to investigate existing or potential opportunities for coordination within selected Federal programs. These include the Construction Grants Program and Water Quality Management Program in response to the Clean Water Act, and Level B Basin Planning in response to the Water Resources Planning Act. The Construction Grants Program is discussed separately, in direct response to Section 516(e) and because it is a grant program for facilities, in contrast to the other two planning programs. Two basic questions are addressed for each of the program areas: What specific mechanisms exist and have been used to successfully achieve coordinated solutions? What constraints and conflicts exist?

Before covering these Federal programs, it is desirable to narrow the definition of coordination to specific types of opportunities that appear important, and briefly review the national extent of the opportunities.

1. Types of Coordination Opportunities

The specific types of opportunities on which this and sections of later chapters focus include:

- Coordinated planning of wastewater facilities, water supply facilities, and water quality measures for a common surface and/or groundwater hydrologic unit.
- Coordinated water and wastewater facility planning for overlapping service areas.
- Reuse of wastewater either to improve and protect a water body or to make additional supplies available.
- Conservation of water through moderation of use to reduce energy and facility requirements for both water supply and wastewater.

There is some overlap between this chapter and the following two. Detailed analyses of the potential for municipal water conservation and wastewater reuse are presented in Chapter IX. Chapter X contains a review and analysis of the major quality problems and quality-quantity relationships involving the use of groundwater, especially as a drinking water supply. This chapter examines these specific types of coordination in the context of implementation within the Federal programs identified.

2. National Extent of Opportunities

Using information from the assessment section, as well as other sources, the extent of possible interactions between municipal water supplies and wastewater discharges is presented in Figures 8.1 and 8.2 for surface and groundwater, respectively. There are about 13,400 municipal outfalls discharging to inland surface waters and about 6,100 community water supply systems withdrawing directly from inland surface waters. An additional 3,900 community water systems purchase surface water from these direct withdrawers. Approximately 20 bgd of surface water is withdrawn for public water supplies, or about 4 bgd more than the quantity of municipal wastewater discharged to inland waters. By contrast, only 400 municipal facilities treat and discharge wastewater via land, compared with over 49,000 community water systems withdrawing

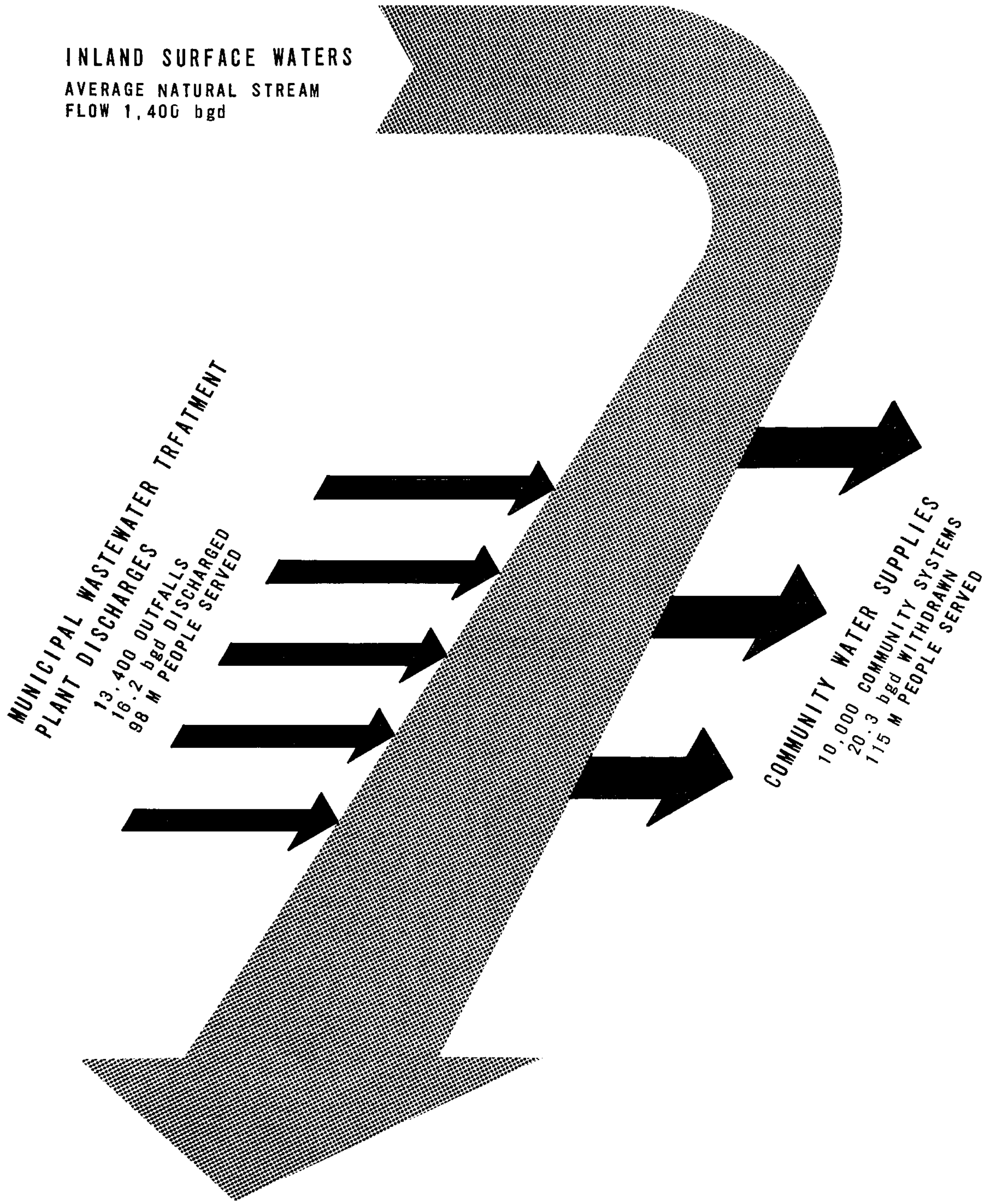

Figure 8.1 WATER-WASTEWATER INTERACTIONS
SURFACE WATERS

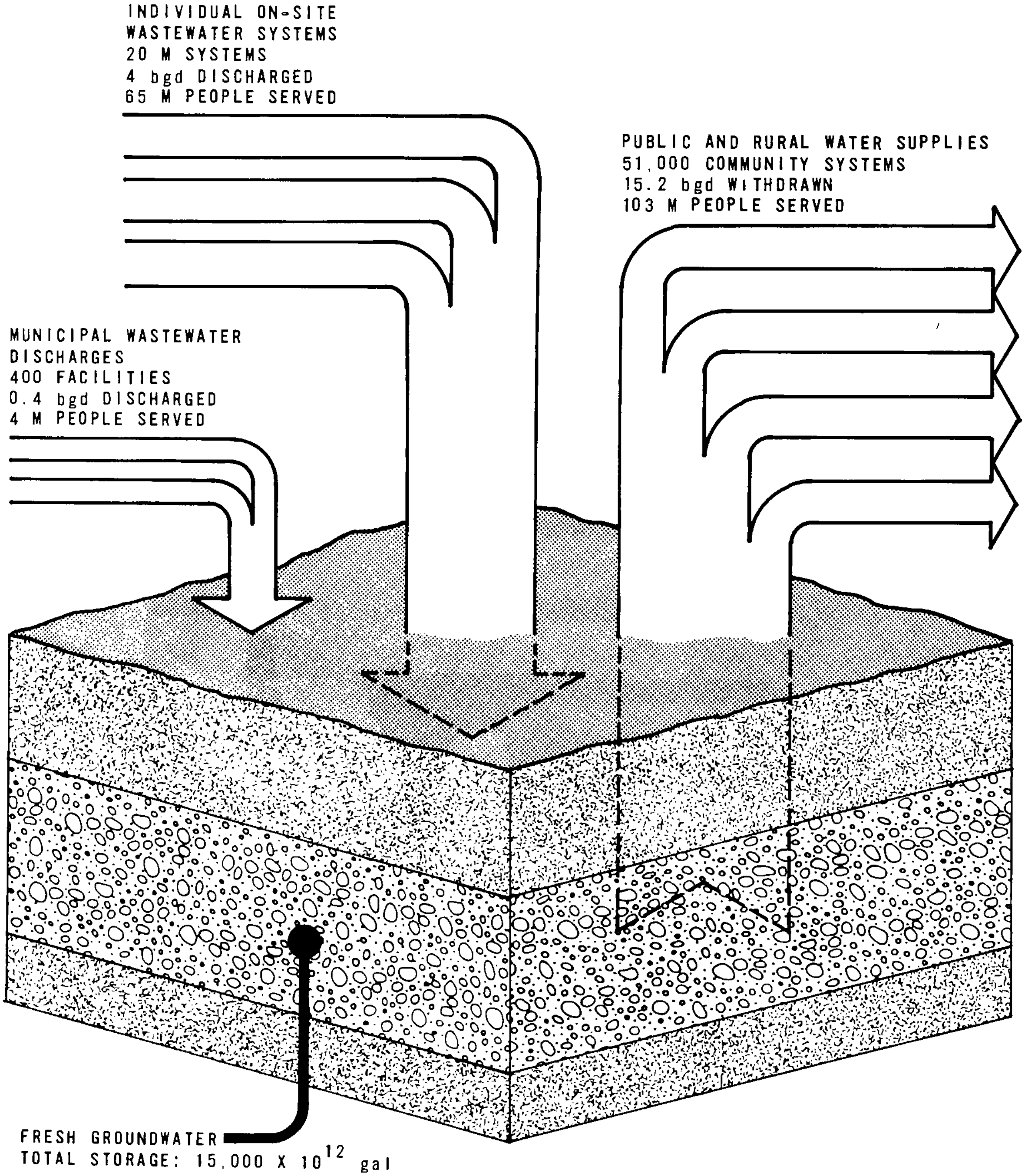

Figure 8.2 WASTE-WATER INTERACTIONS
GROUNDWATER

groundwater. An additional 1,000 systems purchase groundwater from these other systems.

Similarly, the municipal wastewater treated and discharged to land is only about 0.4 bgd, of which only a fraction may actually reach groundwaters, compared with about 15.2 bgd withdrawn from groundwaters. Also shown in Figure 8.2 is an estimate of 4 bgd discharged from about 20 million onsite domestic wastewater systems (septic tanks).

The overall potential for interaction between municipal wastewater discharges and public water supplies appears much greater for surface waters than for groundwaters. There is a greater likelihood, however, for interaction between groundwater supplies and individual, onsite systems. The figures also suggest that in the aggregate only a small fraction (1 to 2 percent) of total streamflow is discharged wastewater or water supply, and an insignificant fraction of the total usable groundwater is affected by wastewater or water supply. Such generalities do not take into account local situations. Additional potential for groundwater interactions is discussed further in Chapter X.

A better indication of the magnitude of surface water interactions locally is provided in a study currently being completed for the EPA (SCS Engineers, 1979). This study attempts to quantify the wastewater impacts on specific surface water supply intakes by summarizing all known upstream discharges. The data shown in Table VIII-1 are extracted from the study results. It is possible to estimate the total population

Table VIII-1

DISCHARGED WASTEWATER REACHING
SURFACE WATER SUPPLY INTAKES

Wastewater in stream flow is greater than -%	Total population affected, millions	
	At avg stream flow	At low stream flow
1	20	25.2
5	1	19.4
10	0.4	15.3
20	0.2	7.6

Source: SCS Engineers, 1979.

using water from surface sources, in which a given percentage of flow is wastewater discharged upstream. For example, 19.4 million people use surface water that may contain greater than 5 percent wastewater flow at low streamflow conditions. Furthermore, the study indicates the relative severity for various river basins and specific cities.

To this point, the information presented here has provided a picture of the existing situation in terms of facilities and quantities. Of equal importance to this study is a brief comparison of the known or potential planning efforts for municipal water supply and wastewater treatment. Several pertinent items from the assessment section and other sources are summarized in Table VIII-2. Numerous planning activities are clearly required including planning in water supply to meet growing demand and quality requirements and planning in wastewater to meet expansion requirements and water quality goals.

Table VIII-2

IDENTIFIED NEEDS MUNICIPAL WATER SUPPLY AND WASTEWATER MANAGEMENT

Water supply

- Municipal supply to increase by 8.3 bgd by 2000
- Municipal shortages in 50% of subregions
- Facility upgrading required to meet IPDWR
- 136 new water treatment plants planned in 1979

Wastewater management

- Wastewater discharges to increase by 4 bgd by 1990
- 8,354 treatment plants planned or needed as of 1979
- 4,962 new outfalls planned by 2000

B. Coordination Through the Construction Grants Process

1. Existing Mechanisms

The Construction Grants Program is involved in the entire process of placing a municipal treatment works in operation, from initial identification and ranking of potential projects and establishing priorities for planning grant funding, to startup of the treatment plant. However, the identification of coordination opportunities, and the broadest scope of decision-making occurs in the earliest phases, especially in the Facility Planning (Step 1) stage. Questions such as funding eligibility of plan components have the greatest impact in the construction stage, but this impact will affect the decisions made in facility planning. The following discussion focuses primarily on existing mechanisms for coordination during facility planning.

Figure 8.3 provides a simple model of the facilities planning process and the activities immediately preceding and following this step. It is intended to highlight steps within the process where coordination opportunities are, or could be, pursued. Prior to starting a facility plan, a need for a project must be identified and placed on the state project priority list. Once the project is high enough on the list to be eligible for funding in a given year, the local agency or grantee applies for and, if approved, receives a Step 1 Grant. The facility planning process then proceeds through a logical sequence of tasks, as shown in the figure, to the final objective of selecting a recommended plan. Upon completion of the facility plan, final review and approval by the state and the EPA is required before proceeding with the Step 2, design, and Step 3, construction, phases.

In practice, the process is considerably more complex than Figure 8.3 suggests. Lengthy and detailed guidelines and memoranda have been issued to provide direction to the process, and it is even possible for states, as in the case of California, to adopt their own guidelines if they have been delegated primary responsibility for administering the program. Regulations and guidelines, by definition, place conditions on the process. An approximate count from the Construction Grants Handbook of Procedures (EPA 1976) shows about 33 requirements or conditions that currently must be met from initial grant application through completion of Step 1, and nine different review procedures for the same process.

The following subsections briefly explore opportunities for coordination in the steps depicted in Figure 8.3.

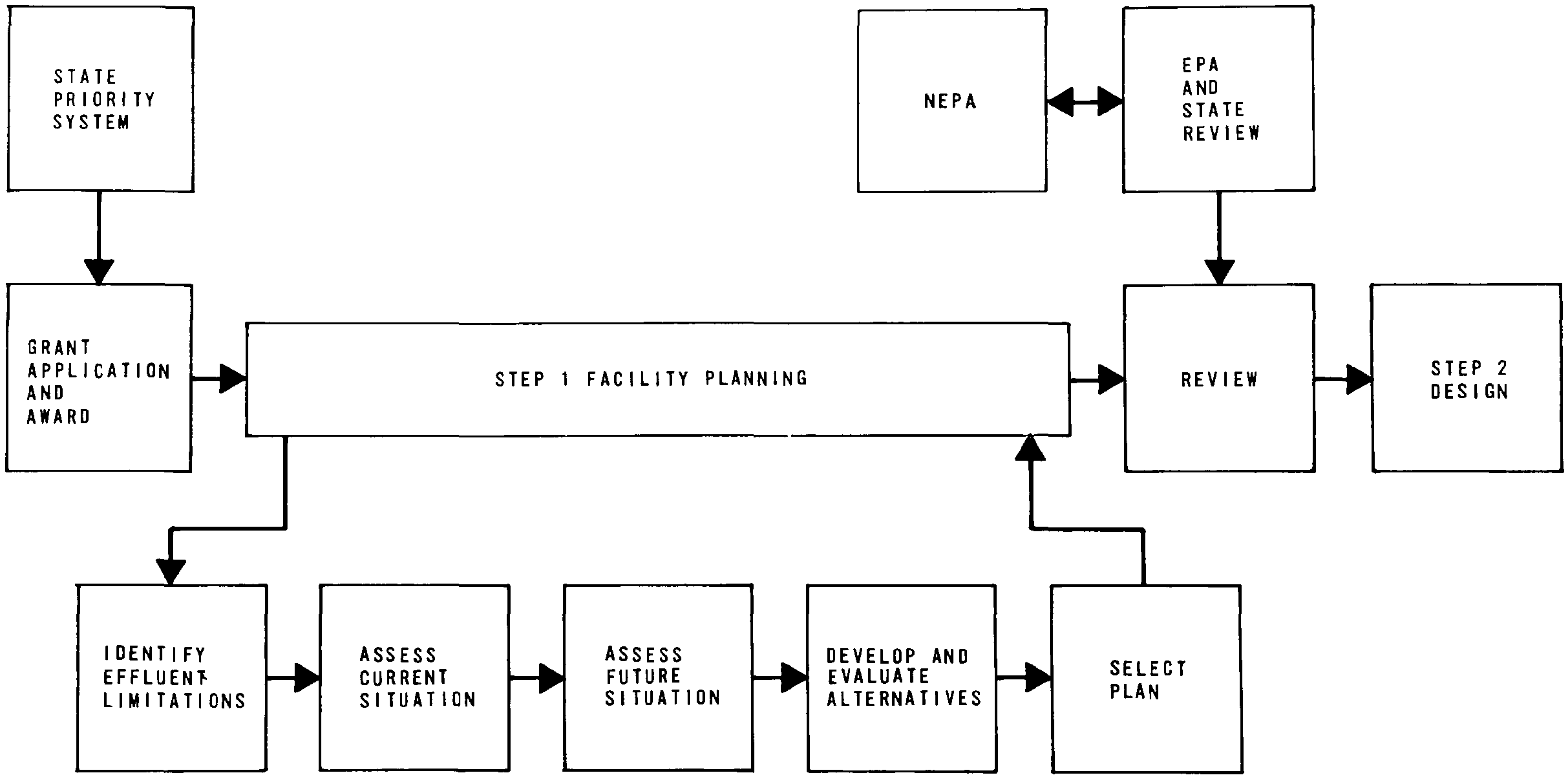

Figure 8.3 THE FACILITY PLANNING PROCESS

a. Project Identification and State Priority List

Identification of needs and possible projects results most often from state and areawide Water Quality Management (WQM) plans. If an identified water quality problem involves protection or improvement of a receiving water used for drinking water supply, a coordination need can clearly be identified. Needed projects are then assigned a priority for funding by the state. Both the law, and the guidelines give states significant latitude and sole authority for specifying priorities. Determination that a pollution problem impacts a drinking water supply could be cause for placing a project high on the priority list. For Step 2 and for Step 3 Grants, innovative and alternative technologies, of which wastewater reuse is one category, may specifically be given higher priorities under the guidelines. The state priority list is also the first point in time that needed projects are identified for public review and comment, one vehicle for soliciting input from water supply interests.

b. Grant Application and Award

The basic plan of study (POS) prepared by the grantee for approval should contain enough information to indicate the needs and the possible range of alternatives to be explored. This is the first opportunity for proposing concepts that would include elements of water supply planning or other specific types of coordination with water supply. Approval of funding for Step 1 costs has traditionally been fairly liberal, including some latitude to study activities not necessarily eligible for Step 2 or 3 funding. For example a "multiple purpose" project may be proposed, in which a plan element, possibly a water supply element, is part of the alternative. Decisions are made after Step 1 is completed on the portions of design (Step 2) or actual construction (Step 3) that are eligible for Federal funding.

The approval process for the POS is subject to the OMB A-95 clearing house comments process, in which Federal agencies involved in water supply planning would have a chance to indicate activities which might overlap.

c. Facility Plan

The facility planning process itself is a logical sequence of steps which culminate in preparation of a final document(s). Activities within these steps can be complex and time consuming. Proceeding from left to right on the bottom half of Figure 8.3, the following points out opportunities to coordinate within each step.

Recognition of water supply impacts can occur early if the identified effluent limitations have taken adequate consideration of such impacts. The next two steps, assessing the current and future situation without the project, have some provision in the guidelines for addressing water supply. To the extent necessary, existing quality, quantity and uses of surface and groundwater are normally described. Consistency between population projections used to assess the future situation and those used for water resources management is encouraged.

The most significant step in the process is the development and evaluation of alternatives. Coordination mechanisms in this step include planning and evaluation methods that permit or encourage discussion of coordination opportunities, and cost-effectiveness and eligibility rules that affect the decision-making process. Items that encourage evaluation of solutions which may achieve some degree of coordination include (1) the legal as well as regulatory requirement to consider wastewater reuse, and (2) capacity sizing guidelines that require a cost-effectiveness analysis of water conservation and wastewater flow reduction techniques whenever an average base per capita flow greater than 70 gpcd is predicted. Equally important, the grantee is generally permitted to develop and evaluate a wide range of solutions, such as the multiple purpose projects mentioned earlier.

Although various alternatives may be developed in which types of coordination have been carefully considered, these alternatives must be screened and evaluated against criteria such as cost and eligibility. A project must first be considered cost-effective within the guidelines to receive funding. Then the local cost share, as determined by the extent to which each project component is eligible for Federal funds, is of considerable interest to the local agency.

Some existing provisions can be used to permit favorable evaluations of coordinated solutions. Projects which use innovative and alternative technologies (of which wastewater reuse is a major category) are given a 15 percent bonus over conventional treatment technologies under cost-effectiveness guidelines and are then eligible for 85 percent funding under the law.

A second provision is the requirement that wastewater flow reduction (e.g. conservation) be considered unless present per capita flow or population is below a certain level. Unfortunately, however, local agencies sometimes consider only measures with limited impacts. There are also obstacles which make implementation of flow reduction very difficult or impossible -- often because the local water supply agency is independent from the wastewater agency and cannot be convinced to implement water conservation measures. Thus, implementation of this provision requires strong coordination among water supply and wastewater agencies, coordination which is not presently a frequent occurrence.

Evaluation and final selection of the plan must include a number of considerations in addition to costs, in particular environmental impacts and public input. A least-cost alternative might not be considered cost effective if the quality or quantity impacts on drinking water supply are significant. Public involvement, including interested water supply agencies, provides another occasion for identifying opportunities or impacts with regard to drinking water supply.

d. Final Review and Approval

Although this step is late in the decision-making process, some mechanisms exist to further identify coordination opportunities or problems. These include: (1) review of the selected plan through the A-95 clearinghouse process, as well as through state and local clearinghouses, (2) final state certification of conformance with WQM plans, and (3) a NEPA environmental review to either issue a negative declaration or require a full Environmental Impact Statement.

e. Summary

The preceding sections indicate that there are a number of mechanisms, expressed or implied, within the existing Construction Grants Program and facilities planning process that have potential for identifying, evaluating, and selecting coordinated plans. The following section presents case studies to illustrate how some of these mechanisms have been used, and to gain insight into some existing constraints and limitations.

2. Case Studies

A useful tool for evaluating the effectiveness and limitations of the Construction Grants Program in achieving coordination with water supply planning is to draw upon actual examples and case studies.

St. Petersburg, Florida, Sacramento, California, and Northglenn, Colorado are selected to illustrative cases. These three were chosen to illustrate a variety of possibilities for, and constraints to achieving coordination. The studies are intended to highlight a few key points unique to each and thus the background and technical aspects are presented only to the extent necessary to illustrate the coordination concept. Of equal significance is the role played by the construction grants process in each.

a. St. Petersburg, Florida

Reuse of wastewater for the purposes of meeting water quality goals as well as providing a supplemental source of water for landscape irrigation is the key technical feature of this project. The city obtains its potable water supply through the West Coast Regional Water Authority from well fields as far as 60 miles inland. Several factors have combined to place severe demands on the available supply in recent years, including below average rainfalls, development and increasing seasonal population, and gradual abandonment of coastal aquifers. Furthermore, urban irrigation demands in the St. Petersburg service areas can account for up to 40 percent of the peak water demand, water quality problems in Tampa Bay have occurred, and advanced treatment is required for any discharge to the Bay.

A schematic drawing of the alternative selected to address both water supply and wastewater quality needs is provided in Figure 8.4. When fully implemented, four wastewater treatment plants with a total capacity of about 62 mgd will serve sections of the city and nearby areas. The plants will provide secondary treatment, filtration, and disinfection. A key feature of the project is the construction of a nonpotable water distribution system within each quadrant of the city. Treated effluent will then be made available to public and private lands for landscape irrigation at approximately one-seventh the cost of potable water. Meters will be provided for each service connection. Over 7,000 acres of green spaces have been committed for effluent irrigation by the year 2000, and 4 mgd of effluent has been requested for industrial reuse. The most important aspect is that peak demand on potable water supplies will be reduced substantially. It is estimated that use of the effluent may delay the need for additional fresh supplies by 10 to 15 years.

A second feature of the project is that effluent which is not used for irrigation, as in periods of high precipitation, will be injected and stored in a deep aquifer beneath the city. This aquifer is no longer usable as a public supply. The thinking is that stored water could eventually be withdrawn and reused in the future if there is additional demand for nonpotable water.

The St. Petersburg project illustrates how the construction grants process has been important in providing an implementing mechanism. Various stages of planning, design, and construction for some of the facilities have occurred since 1972. The most recent facilities plan, completed in 1978, addresses a number of issues including revised population growth, service area planning, and facility capacities. In addition, this plan includes the effluent distribution system to serve the regional treatment plants.

Several aspects of the role played by the construction grants process are of interest. The effluent reuse portions of the project were considered grant eligible because the overall project was shown to be more cost effective than providing full advanced wastewater treatment

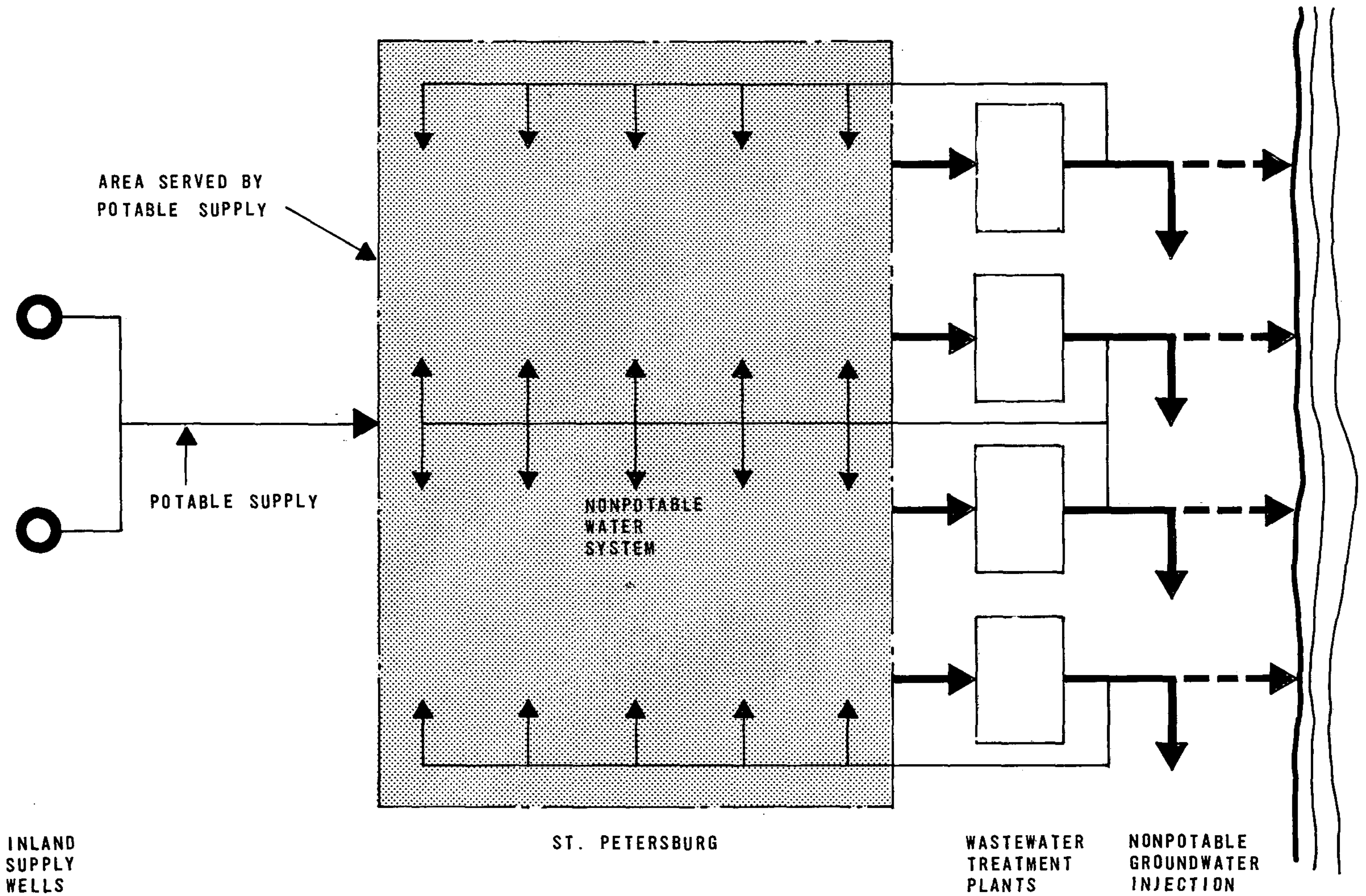

Figure 8.4 CASE STUDY OF ST. PETERSBURG, FLORIDA

and continued discharge to the receiving waters. Previous grant eligibility levels were set at 75 percent funding. The city is now trying to get approval for 85 percent funding for remaining portions of the work based on the fact that the project represents an innovative and alternative concept. The input of construction grant funds has helped to make the cost of reclaimed water very attractive to users.

Other factors are also important in the successful culmination of this planning. Strong local political commitment and extensive public education since 1972 have been critical to gaining support and acceptance of the concepts. An extensive research effort, funded almost solely by the city, was conducted, particularly with respect to virus control. Institutionally, water supply, wastewater management, and the reclaimed water system are under the control of the City of St. Petersburg, Department of Public Utilities except for the small areas outside the city that discharge to the regional treatment plants. This arrangement provides close coordination and control over all aspects of the use of the water and simplifies implementation of the project.

In summary, St. Petersburg represents an example of coordination through reuse that is being carried out. Strong local identification of needs and concepts has been instrumental in implementation of the project. Because a clear water quality problem was identified, the construction grants process was a workable vehicle to achieve the coordination.

b. Sacramento, California

Sacramento illustrates a case where aspects of surface water supply played significant roles in a regional wastewater planning process. A previous study examined many details of the legal, institutional, and technical framework surrounding the planning and decisionmaking process that spanned several years in the early 1970's (NSF, 1976). The purpose here is to focus only on the interactions with water supply in Sacramento's regional wastewater planning effort.

The City of Sacramento and surrounding Sacramento County are situated at the confluence of the American and Sacramento Rivers. Both are major water courses with fully regulated flow regimes. Following rapid growth since the 1940's, the city and county populations have reached 260,000, and 690,000, respectively. The number of wastewater treatment facilities in the metropolitan area had proliferated to 21 plants by the late 1960's, discharging to both the Sacramento and American Rivers. The location of these plants is shown in Figure 8.5. Although there were no chronic water quality problems in the rivers owing to their large volumes, a number of items pointed toward a need for improved wastewater management in the area. These included hydraulic and organic overloading at the City Main Plant (Number 13) as well as others that contributed to localized water quality problems and odors, and combined sewer overflows that bypassed the treatment plants and discharged directly to the rivers. To remedy these problems and plan for the future, both the city and county originally proceeded independently with planning efforts. Eventually the efforts were combined with the formation of the Sacramento Regional County Sanitation District.

The master alternative finally selected was one in which essentially all existing treatment plants in the greater Sacramento area are replaced by one large regional facility adjacent to the City Central Treatment Plant (Number 15). Secondary treatment will be provided with the flexibility of later adding nitrification if necessary. A new interceptor system will transport the wastewater of the area to the regional plant, as shown in Figure 8.5. Only the City Main Plant will be retained to provide treatment for combined sewer overflows. As of early 1979, construction of many of the facilities is nearing completion.

A number of factors led to the selection of this plan over others. Of particular interest to this study, however, was the decision made by the California Department of Public Health and the Regional Water Quality Control Board to prohibit any wastewater discharges within several miles above local water supply intakes. There are several existing or proposed surface water intakes in the area, as shown in the Figure 8.5. This decision favored the regional wastewater plant alternative compared to other options which would have required an extended outfall to a point below the proposed water supply intake. A second consideration

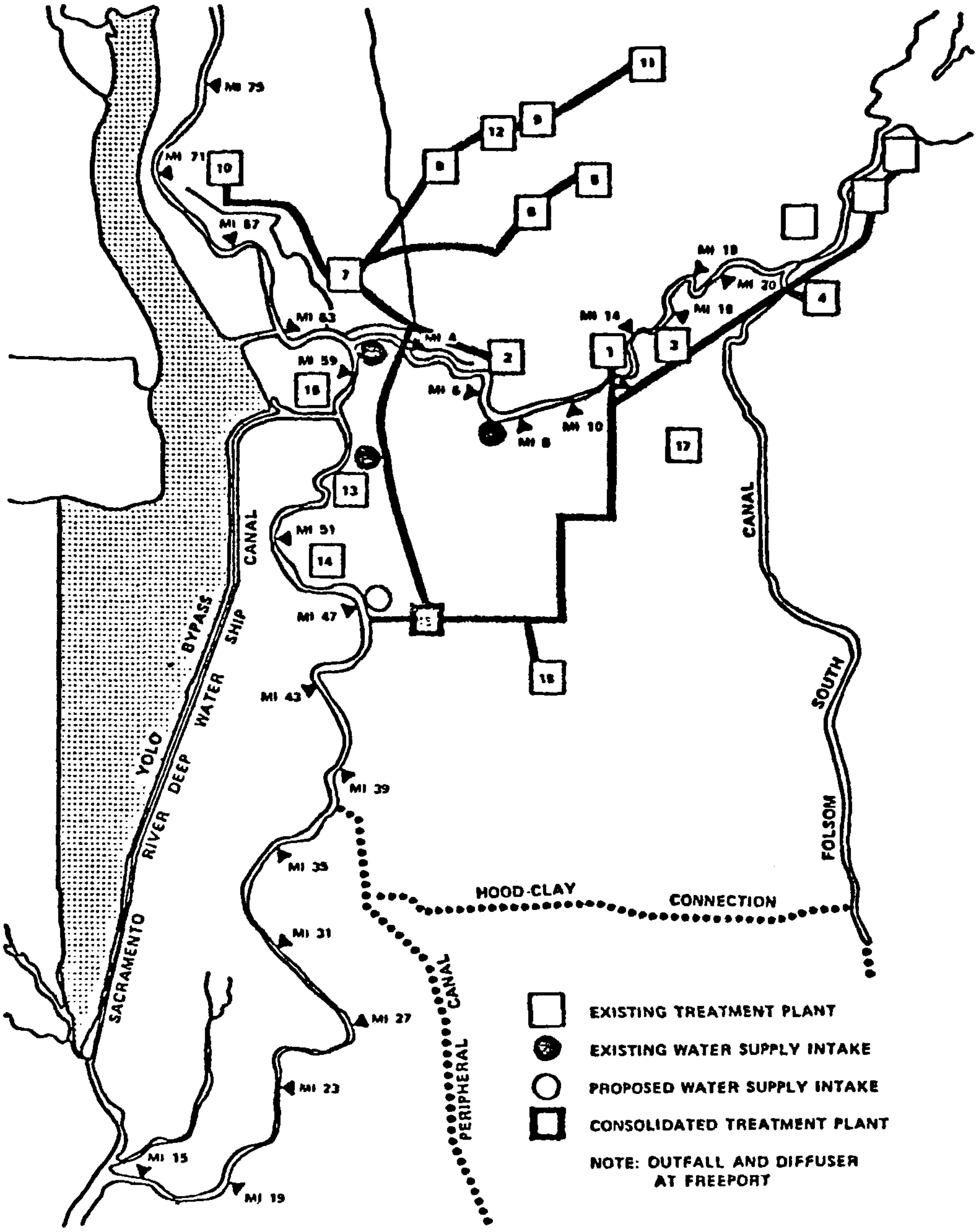

Figure 8.5 CASE STUDY OF SACRAMENTO, CALIFORNIA

Source: Weston (1975)

was that formal opposition to wastewater reuse for irrigation was expressed in neighboring Yolo County, an item that had been an advantage of one slightly more cost-effective option.

In addition to the consideration of wastewater discharge impacts on local drinking water supplies, a different form of interaction with water supply planning was also evident. Water quality planning is greatly affected by the river flows, which in turn depend on present or future planned river regulation and diversion. Important decisions which would alter the flow regimes of both rivers were uncertainies at the time of planning. These included possible construction of the Peripheral Canal and alteration of flows in the American River by the Bureau of Reclamation. This had some impact on the decision to provide maximum treatment flexibility such as the future ability to nitrify at one regional treatment plant.

Although wastewater planning for Sacramento began before PL 92-500 was enacted, the law was in effect by the time the final project report was prepared. All of the eligibile design and construction have since been funded under the Construction Grants Program. The prohibition of discharges within a few miles above water supply intakes in this situation is a legal perogative of the State of California in setting discharge requirements. Therefore, a cost-effective solution that complies with this requirement is a project eligible for Federal funding. Water supply considerations definitely did affect the wastewater facility plan chosen.

On the other hand, more integrated and cost-effective solutions may have been possible if improved planning mechanisms had existed or special coordination efforts had been made. For example, it may have been possible to plan the proposed water supply intake for a different location with a significant shortening of length for the wastewater outfall or interceptors. However the grantee (local agency), working within the framework then available, preferred to avoid any interference with the proposed intake. This may have been for any one or a combination of several of the following reasons: (1) simply to avoid the painful and time consuming negotiations that "coordination" appeared to entail, (2) perceived difficulties in establishing appropriation water rights for the intake at an alternative location, or (3) a local view that the funding of any increased expenditures involving water supply components would require 100 percent local funding and that this was likely to be much greater in terms of dollars than the 12.5 percent local funding required for wastewater interceptors or outfalls eligible for support under the Construction Grants Program.

Thus, there was an awareness of water supply considerations in the case of Sacramento, especially in terms of setting in-stream water quality standards and discharge prohibitions and in recognizing future flow uncertainties due to proposed major water projects. The planning process used did not, however, develop a joint water supply/wastewater analysis in its search for a facilities plan and such an analysis was not already available. This may indicate: (1) an inadequacy of earlier broad water resources/water quality planning which should establish a more definitive context for wastewater management prior to facilities planning; (2) the need for a slightly broader view in facilities planning itself; (3) development of artificial limitations to the scope of analysis due to institutional or funding considerations; or (4) a combination of these.

c. Northglenn, Colorado

From a conceptual standpoint, the proposed Northglenn project represents an innovative approach to solving a municipal water supply problem and managing municipal wastewater in one project. At the same time, it serves as an example of complex legal and institutional issues and some limitations of the Construction Grants Program.

The basic concept is illustrated in Figure 8.6. Currently, the City of Northglenn receives all water and sewer services from the neighboring City of Thornton. Under the proposed plan, Northglenn has entered into an agreement with an irrigation company to aquire rights to ultimately divert up to 7,800 acre-feet of water annually from nearby Standley Lake. A water supply pipeline and water treatment plant will be constructed to supply this water to the city. Collected wastewater

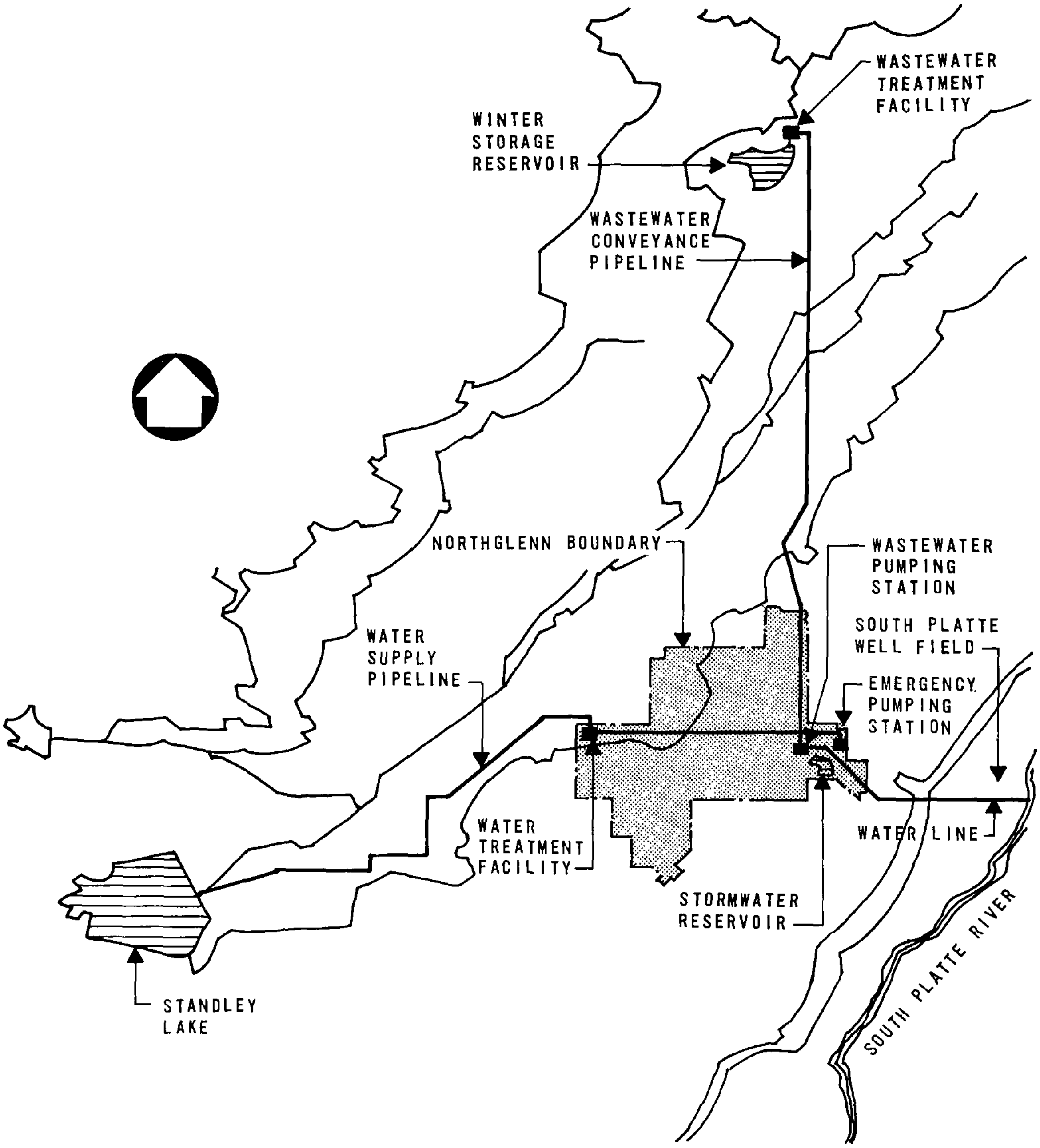

Figure 8.6 CASE STUDY OF NORTHGLENN, COLORADO

will be pumped approximately 10 miles north of the city to the site of a wastewater treatment plant and storage reservoirs. The treated wastewater will then be released into an adjacent canal to be used by farmers during the growing season. Supplemental wells will be developed to provide makeup water (approximately 35 percent of withdrawals from Standley Lake) to replace the estimated 20 to 25 percent consumptive municipal use, plus an extra 10 percent bonus as a further incentive to the irrigation company. An urban stormwater retention basin which can also be pumped into the wastewater management system is an additional part of the project. Under the concept, Northglenn would have full control over all aspects of water supply and wastewater management.

Although the concept is straightforward, the planning and implementation process has been difficult and has involved not only the construction grants process, but also the 208 (WQM) process. In the original areawide water quality management plan for the Denver Council of Governments, Northglenn was treated as part of the Thornton system, and ultimate plans called for treatment of this wastewater within the Denver Metropolitan system. At the same time, Northglenn elected to pursue other solutions for economic and political reasons, as well as a concern over plans to condemn agricultural water rights by the City of Thornton. Northglenn completed a planning effort in 1977 to examine water and wastewater alternatives without the use of construction grants funding. At this point there was no identified water quality or wastewater treatment need to allow placing the project on the state priority list. Out of this planning, a basic water management system was developed. In July of 1977, the electorate approved a $31 million bond issue to underwrite the costs of the project.

At this point, Northglenn took its proposed plan to the State Water Quality Control Commission to request that the project be placed on the state priority list for construction grants funding for the wastewater facilities. State approval was eventually given but was contingent in part on revision of the 208 plan. A plan revision was ultimately approved in 1978, although there was considerable technical, economic, and political controversy over the plan modification. In the meantime, Northglenn proceeded to prepare a formal facility plan document without receiving a Step 1 grant. Subsequently, the city completed much of the design work and has the project essentially ready for construction as of early 1979.

While the state has given approval for retroactive Step 2 funding and Step 3 funding, several issues have delayed EPA approval of the grants:

- The Step 2 grant approval is waiting a legal decision on the consultant procurement procedures used, an item not related to the technical aspects of the project but which resulted from design being done without prior Step 2 grant approval.

- Although water rights have already been purchased from the eastern slope, a water rights adjudication process is still necessary. The EPA regional office sees this as a significant hurdle. Northglenn officials believe it is a pro forma procedure and argue that in any case they have other possibilities as backup. Although Northglenn would like to proceed, EPA is expected to insist on prior completion of the legal process which may take up to one year.

- The environmental appraisal for the project, tentatively issued earlier with a negative declaration, must be reconsidered and revised by the EPA regional office. Several issues have been newly identified or can now be addressed more specifically:

    - The treatment facilities and storage site are now site specific so a more accurate appraisal of environmental impacts is now possible.

    - Secondary environmental impacts may occur on farm production due to transfer of water from one sub-basin to another and this possibility must be addressed.

    - A potential has been identified for future small community withdrawal of drinking water supplies from irrigations ditches proposed to carry Northglenn effluent; this possibility must also be addressed.

It is estimated that four to six months will be required to complete this appraisal.

- The amount of funding eligibility for project construction (step 3) remains to be resolved. Although EPA views the project as primarily a water supply project, the agency did agree to consider funding those portions of the project which enhance water quality in the environment. Construction grant eligibility will probably be determined based on the least costly conventional pollution control alternative.

Several observations can be made in summarizing the Northglenn situation. Basic motivation for the project was a locally perceived need for alternative solutions for both water supply and wastewater management purposes. The solution represents a technically and environmentally sound integration of water and wastewater planning (assuming the remaining environmental issues are resolved favorably). Institutional and legal issues have been complex (e.g., negotiating a water rights transfer agreement), but local initiative has succeeded in overcoming most constraints. Construction grants funding will apparently be used to partially support construction of the wastewater facilities, but the planning process and proposed plan have tested the legal limits of the program. Some of the detailed constraints have already been pointed out. The basic problem, however, would appear to be that the motivation for the project, though technically and environmentally attractive, was not principally a response to an existing water pollution problem. Legally, the Construction Grants Program is basically a remedial program and is not intended to provide for future growth.

3. Effectiveness and Constraints

Referring back to the four general types of coordination activities listed in the introduction, this section will draw upon the case studies, other examples, and the existing mechanisms presented in Section 1 to assess the effectiveness and constraints to achieving coordination through the construction grants process.

a. Coordinated Planning for a Common Surface and/or Groundwater Unit

To fully coordinate water and wastewater planning for a common water unit, the planning and decision-making activities must have the capability to: (1) recognize the opportunities or problems and (2) have tools to implement a solution. Opportunities should be recognized as early as possible in the planning process. Under facilities planning, this includes identification of any potentially affected water supplies, and establishing quality criteria for use in evaluating alternatives. Identification of potentially affected water supplies should ideally occur in developing background information on the current or future situation. There is provision in the current guidelines for identification of present quality and uses of water within the planning area, and this may be sufficient in many cases. However, potentially affected water supplies outside the immediate planning area may not be as readily identified. In the case of Northglenn, for example, the possible impact on a potential future drinking water supply downstream in the canal (whether or not this proves significant) was not identified until very late in the review process. In the case of land application of wastewater or sludge, the hydrologic characteristics and location of supply wells of the area must be thoroughly understood in order to identify any potentially affected water supplies. Identifying future water supply planning may prove more difficult in cases when the water supply agency is a totally separate entity from the wastewater planning agency.

Establishing criteria for wastewater discharges potentially impacting water supplies is often a greater problem than simply identifying the potential. General discharge requirements for which alternatives may be developed are usually based on receiving water quality standards which may not consider direct impacts on water supply. On the other hand, stringent requirements may be established in relation to specific alternatives. In the case of Sacramento, the final decision to prohibit all upstream discharges within several miles was not made until after many other alternatives were evaluated. Another published case study of the Huron River in Michigan shows how a complex and involved process of evaluating potential water supply impacts ultimately led to the rejection of a wastewater management alternative (Culp, Wesner, and Culp, 1978). Identifying quality relationships and impacts on water supplies from wastewater alternatives is complex and may constrain or complicate wastewater facilities planning.

With regard to the tools for implementing a solution, construction grants can be a vehicle although opportunities for some cost-effective solutions may be missed. Projects can be funded that clearly meet the objective of protecting a drinking water source, as in the Sacramento example. Another example of a project that used construction grant funding and resulted in protection of both drinking water quality and quantity is the Occoquan, Virginia Wastewater System (Culp, Wesner, and Culp, 1978). In this case, extensive advanced treatment and process reliability were incorporated into the project. The lack of Federal funding for water supply components, either through wastewater construction grants or any other program, may inhibit other solutions, as pointed out by the Sacramento example. Another example in which relocating a water supply intake might have been more cost effective is in the case of Hopewell, Virginia. A recent study indicates that, under several theoretical conditions, providing GAC treatment for water supply might be less costly and more beneficial than providing advanced wastewater treatment upstream (Culp, Wesner, and Culp, 1978). The lack of Federal funding, however, would generally preclude this from being seriously considered as a wastewater management alternative in the facilities planning process.

b. Coordinated Facility Planning for Overlapping Service Areas

St. Petersburg and Northglenn both provide examples of this type of coordination. However, there are other, less obvious ways in which coordinated planning may have some benefits, and the Construction Grants Program may or may not be able to play a role. These are the use of common planning, population and land use assumptions for both water supply and wastewater planning. Facilities planning requires that population projections be established and land use plans be reviewed or estimated as part of assessing the future situation. Ideally, these should be consistent with water supply planning assumptions to provide benefits such as balanced sizing of facilities or common planning for future service areas.

Except as relevant to flow reduction (water conservation) measures, however, such coordination is not a condition to facilities planning. Difficulties with incorporating such a condition in the process include: (1) water supply planning may be done by an entirely different agency, (2) water supply planning may not be occurring at the same time, (3) water supply planning may be based on very optimistic projections of growth and (4) the water supply agency may project different locations of growth. One potential means for requiring coordination would be in the case where another Federal agency is involved in water supply planning. Such is the case in the Atlanta area where wastewater facility planning and water quality management planning have been occurring simultaneously with water resource planning under the Corps of Engineers. Another item to be noted is that the facilities planning guidelines do not specifically require identification of the future availability by source of the quantity of water supply to support the projected population and wastewater flows. Such considerations may surface in the identification of secondary environmental impacts.

c. Reuse of Municipal Wastewater

Evaluation of wastewater reuse as an alternative water pollution control method, is clearly encouraged under the Clean Water Act and in facilities planning. This is the case in St. Petersburg, where a reuse project that has the effect of supplementing municipal water supplies is a cost effective solution to a water quality problem. Incentives exist both in terms of cost effectiveness guidelines and funding eligibilities. Elements of the project such as the effluent distribution pipeline network are eligible for funding.

There are other types of reuse projects, however, for which the use of Construction Grants Program funding is much more constrained. This occurs when a reuse project has as a main purpose of supplementing water supplies, or is not cost effective in terms of meeting a water quality need only. Currently, fairly liberal funding is available to consider a variety of reuse alternatives under Step 1 planning, but grant eligibility is largely restricted to pollution control and based on the cost of the most cost-effective alternative. Such projects are the subject of EPA's multiple Purposes Guidelines task force study.

d. Municipal Water Conservation/Wastewater Flow Reduction

Although none of the case examples dealt specifically with the issue of water conservation in relation to the construction grants process, several observations can be made. It was previously pointed out that analysis of flow reductions measures which include water conservation techniques must be a part of the cost-effectiveness analysis procedures when average daily base flows exceed 70 gpcd (communities less than 10,000 population are exempted). The regulations further provide that implemented programs must be "cost effective, supported by the public and within the implementation authority of the grantee or another agency willing to cooperate with the grantee". The latter part of the statement recognizes the constraint that a number of wastewater agencies may have little authority to implement water conservation measures. For example, a regional sanitary district may serve several cities and unincorporated areas, all of which provide their own water supply.

A second drawback is the fact that the Construction Grants Program provides no funding for implementing a water conservation program other than a public information program. On the other hand, other flow reduction measures such as correction of excessive infiltration are eligible. In the absence of other demonstrated benefits or incentives, reducing the size of wastewater treatment facilities (and therefore the amount of the Federal grant) alone is not an incentive for a strong, locally funded water conservation program. But reduction of the local share, operation and maintenance costs, and household costs are real local incentives if they are understood as such. Increased interest in these savings might be generated by a construction funding bonus or some other reward for communities which have voluntarily undertaken strong water conservation programs so that flows have been reduced below 70 gpcd, but this incentive is not now available.

4. Summary

The present construction grants process contains legal and administrative measures for enabling a significant amount of coordination to take place between wastewater and water supply planning. If opportunities are going to be realized, they need to be recognized during the facilities planning process, and incentives must be available to allow coordinated solutions to be evaluated and selected. Examples of constraints and limitations include: (1) not recognizing potential impacts on water supply early in the planning, (2) not having adequate water quality/discharge requirements identified with respect to water supply impacts, (3) lack of flexibility of Federal funding of water supply components, (4) water supply and wastewater planning being conducted by separate entities, (5) limits to grant eligibility for certain reuse projects, and (6) insufficient positive incentives for promoting water conservation.

C. Coordination Through Water Quality And Water Resources Planning

The Construction Grants Program is very specifically oriented toward building the publicly-owned facilities needed to control municipal water pollution. In contrast, water quality and water resources planning are expected to take a broader view of overall water- and environment-related needs and interrelationships. Indeed, if these broader planning programs are working well, they should identify most needs for facility construction and should provide reliable information for prioritizing them. Given this orientation, the broad planning programs may provide the best opportunity to identify cases where water supply/wastewater management coordination should occur and to orient facility planning toward the types of coordination which appear to be most fruitful.

1. Existing Federal Mechanisms

Two major Federal planning programs are discussed in this section to identify coordination which presently occurs and additional coordination opportunities which might be captured. These programs are:

- EPA's Water Quality Management Planning (WQM) and
- WRC's Level B (or Section 209) Planning.

There are, of course, other planning programs which make important contributions, e.g., Corps Urban Studies, Bureau of Reclamation General Investigations, WRC Title III Support to States, and State Water Resources Planning in general. The two programs selected above are representative, however, and they have key differences which provide useful insights.

a. Water Quality Management Planning

As an evolution and consolidation of EPA's planning and management programs under the Clean Water Act, new comprehensive regulations for Water Quality Management were recently promulgated. These regulations further implement the requirements of Sections 106, 208 and 303 of the Act with emphasis on the continuing planning and implementation phase of state and local activities begun under earlier, superseded regulations. Figure 8.7 illustrates the several activities and products which now constitute Water Quality Management. The following items in the overall WQM program deserve special mention with respect to water supply/wastewater management coordination:

- The Water Quality Problem Assessment activity required annually may be expanded to an overall environmental problem assessment, for example, encompassing the Clean Water Act, Safe Drinking Water Act, and Resource Conservation and Recovery Act. This provides the opportunity to identify water supply and wastewater problems which are related to each other and require coordinated solutions.

- The State Strategy prioritizes the problems identified through assessment and develops a five-year approach for addressing them including tentative assignments of responsibilities, cost estimates and funding sources. Since the strategy is used as a preview document and basis for discussion in developing the annual State/EPA Agreement, it may also be prepared as a joint, integrated strategy under the above referenced legislation. This allows related water supply and wastewater problems to be programmed for joint consideration.

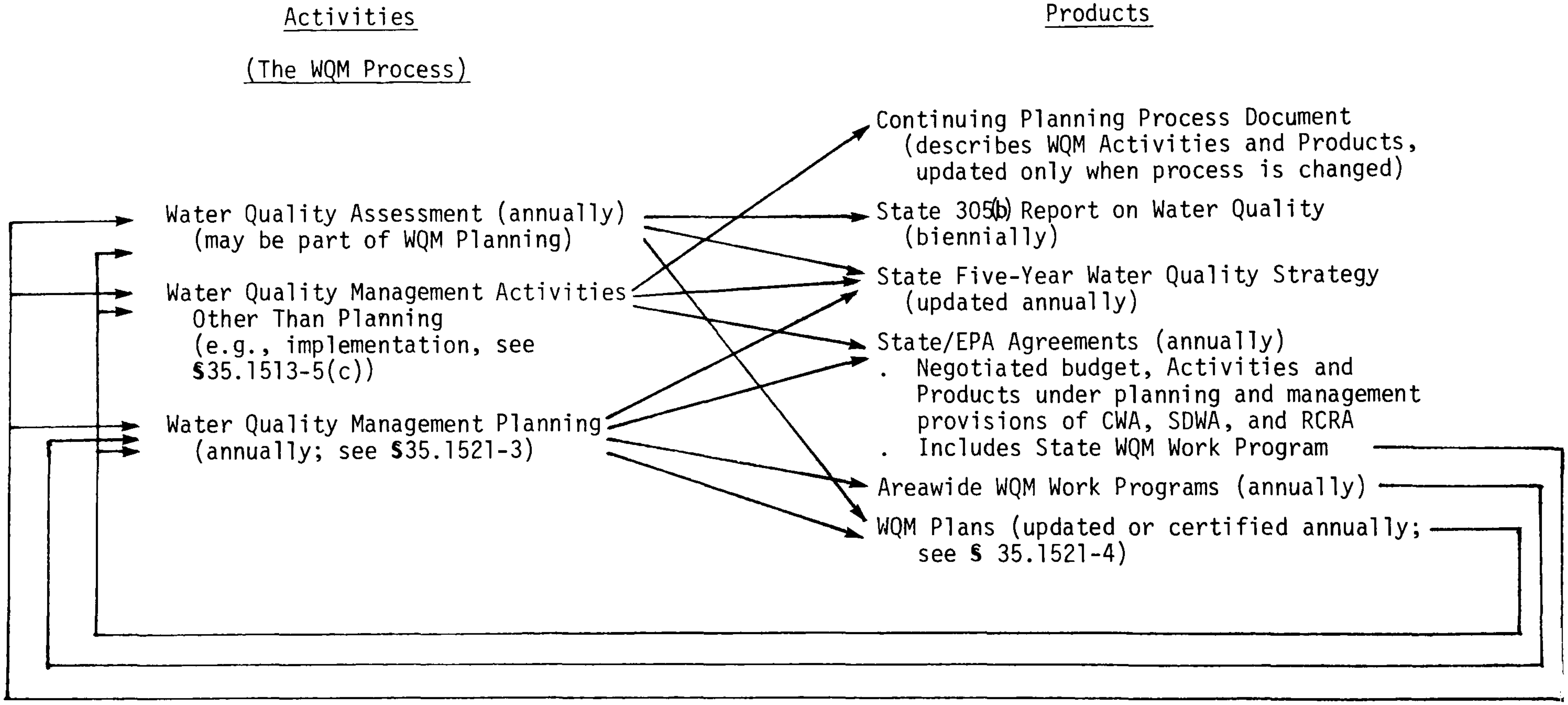

Figure 8.7 WATER QUALITY MANAGEMENT UNDER NEW EPA REGULATIONS.

- The State//EPA Agreement is a decision document which specifies what the state is to do using EPA funds during the upcoming fiscal year. It includes all management and planning activities and moneys under the Clean Water Act, Safe Drinking Water Act, and Resource Conservation and Recovery Act. It relates the agreed-upon work elements to the priority problems to be addressed. One component of the Agreement is the WQM work program which specifies outputs, budgets and time schedules for each work element. If water supply/wastewater coordination is to occur, this is the place which determines how and when a coordinated solution will be found.

- Water Quality Management Planning is the one WQM work element (out of approximately 16) which is most likely to be the vehicle to find coordinated solutions to water supply/wastewater management problems or interactions. Specifically:

  - The relationship of water quality to land use and water resources must be considered while addressing the various WQM Plan program areas.

  - Coordination is required with potentially affected agencies including general purpose units of local governments, proposed and designated management agencies, and other affected state and Federal agencies (e.g., recreation, air, solid waste, drinking water and fish and game offices).

  - Within the "Municipal and Industrial Needs" program area, the plan must set forth information appropriate to support subsequent facility planning including proposal of appropriate programs to support municipal water conservation.

  - Within the "Water Quality Standards" program area the plan is to suggest revisions to state water quality standards as appropriate to meet water quality goals which may be based on the water body's use as a drinking water source.

  - Within the "Conservation" program area, the plan is to identify water conservation needs and practices to achieve and maintain water quality standards and to ensure efficiency in municipal wastewater treatment.

Beyond these major components and provisions of WQM, there are several overall properties of the program which must be recognized:

- A strong partnership between EPA and the state or areawide agencies is emphasized. Within this partnership theme, the substantive goals and requirements of the Clean Water Act are made clear, major procedural requirements are defined, a sense of Federal priorities is given and financial support is available. The state and areawide agencies are then given the responsibility for doing the planning and management; i.e. for addressing the local problems, finding solutions (which respond to the Federal requirements and have state/local support) and implementing them. State and local accountability is maintained by cultivating a strong state/local interest in having a workable partnership.

- WQM is a continuing program with an ongoing planning and implementation component rather than a one-time "comprehensive" plan which is developed and then forgotten. This continuing nature allows efforts to be focused on the most important problems first and later efforts to be devoted to other relevant topics; thus the program is kept manageable. It allows an EPA/state/areawide partnership to develop and it creates a strong state/local interest in performing responsibly because future Federal assistance and continued delegation of responsibilities depend on it.

- WQM emphasizes implementation. The planning activities are closely related to the management activities. Indeed, the State/EPA Agreement and Work Program specifies a combination of planning and implementation activities for the year. Thus there is a combined commitment to and accountability for planning and implementation. Furthermore, the planning component is required to identify specific management agencies for implementing each plan program, to develop an implementation schedule, and to obtain their commitment to do so. Clearly, the management/implementation agencies must believe in the plans developed and to do so they must be involved throughout the planning.

Unfortunately, during the initiation of planning and management under PL 92-500, some of the intended emphasis on continuing, stable programs and on implementation was not achieved. Improvement in these areas has been a primary objective of recent regulation revisions and EPA is committed to and enthusiastic about WQM program success with these renewed emphases.

b. Level B (Section 209) Planning

In response to the Water Resources Planning Act of 1965 (PL 89-80), the Water Resources Council guides and, in some cases, conducts multi-agency water and related land resource programs. Section 209 of the Clean Water Act calls for the President, acting through WRC, to prepare Level B plans for all basins in the U.S. by January 1, 1980.

Level B planning is an intermediate level of planning between Level A studies (which are geographically extensive and very broad in scope) and Level C studies (which are project oriented). Level B is intended to resolve critical near-term (next 15 years) and mid-term (15-25 years) issues through integrated consideration of water quality, water supply, flood damage reduction and other relevant water and related land resource programs as well as institutional coordination at all governmental and private levels (WRC, 1976). The planning is conducted under the guidance of the WRC Principles and Standards (1973, 1979) with strong emphasis on both national economic development and environmental quality objectives.

The following are highlights on how Level B planning is done in terms of the four major outputs produced and what opportunities are present for water supply/wastewater management coordination:

- A Proposal to Study (PTS) is developed in response to a perceived regional or river basin need which is beyond the scope of present agencies or programs; for example, a conflict may exist between water supply development and water quality maintenance and the agencies primarily responsible for each may view Level B as a vehicle for achieving resolution. The PTS is submitted to WRC by the River Basin Commission or, where no commission exists, by the regional sponsor working with WRC in assessment activities. WRC then decides whether to include the study in its budget request by evaluating the proposal in light of eight major criteria which stem from national policies, statutes, and objectives (WRC, 1976):

  - Policy conflicts: Are essential water and related land activities hindered or prevented by conflicts of policy which could be resolved through Level B studies?

  - Water use conflicts: Can a Level B study help to resolve conflicts in allocation of water supplies?

- Agreement with Water Resources Council Policy: Will studies be conducted consistent with WRC Policy on study management, funding levels, use of Principles and Standards, adequacy of data, etc.?

- Urgency: Can the results of the proposed Level B study permit a timely response in resource decision-making from a national and regional perspective?

- Non-Federal support: Will State and local agencies actively participate in the study, in addition to providing financial support?

- Energy: Can potential water resources proposals help meet national and regional energy requirements?

- Water Quality: Do the areas have substantial water quality management problems, particularly those that are a consequence of urban-industrial concentrations (Sections 208-209)?

- Land use vs. growth pressure: Do the areas where Level B studies are needed have water and related land resources problems associated with local or regional growth pressures?

Opportunities to address problems and conflicts and to achieve coordination between water supply and wastewater management are particularly apparent in light of the four criteria on policy conflicts, water use conflicts, water quality, and land use versus growth pressure.

. If funding occurs, a Plan of Study (POS) is developed to provide additional information and clarification on the specific issues or problems to be addressed, how they are to be approached, and what specific activities, products, budget and time schedule are involved. The POS is developed within the first three months of the study. Special emphasis occurs during POS development on identifying, characterizing, and assessing the major conflicts, problems or opportunities which cut across traditional functional and agency boundaries. Then the Level B effort is focused on a few of these in order to achieve meaningful results within realistic time and budget. Clearly, resolution of water supply/wastewater management conflicts is a prime candidate for POS emphasis.

. First Cut Plans are developed and published within six additional months. These include an initial plan (which projects the future assuming no action is taken to change present trends), a plan emphasizing national economic development and a plan emphasizing environmental quality. The idea is to present a range of possibilities very early in the study in order to stimulate interest and comment.

- The Draft Report with a recommended plan and a specific implementation program is then produced within another six months.

Within the structure established by these four major outputs and the Principles and Standards, Level B is able to give strong emphasis to the several features designed to allow its special type of contribution:

- Any functional area pertinent to water and related land resources can be addressed.
- Any Federal, state, or local agency with an interest in the problems being addressed is invited to be an active participant on the study team.
- Minimal restrictions are placed on what the Level B study must or must not address; the study team has wide discretion to initiate creative, practical, implementable approaches for resolving problems.

2. Examples

In order to more tangibly illustrate abilities and weaknesses of the broad planning programs in water supply/wastewater management coordination, the following specific examples are presented.

a. Old Colony Planning Council 208

Ten towns in eastern Massachusetts belong to a regional planning council (Figure 8.8). The planning area is 172 square miles with a 1975 population of 200,000. The topography of the area is flat with swamps and a few lakes. Glacial till, sand and gravel are the major formations. Five of the ten towns use surface water supplies as a drinking water source, but these ponds are fed by groundwater in the underlying sand and gravel deposits. Public wells in the other towns also tap these sand and gravel aquifers. Some private wells obtain water from glacial till and bedrock supplies, although flow rates are

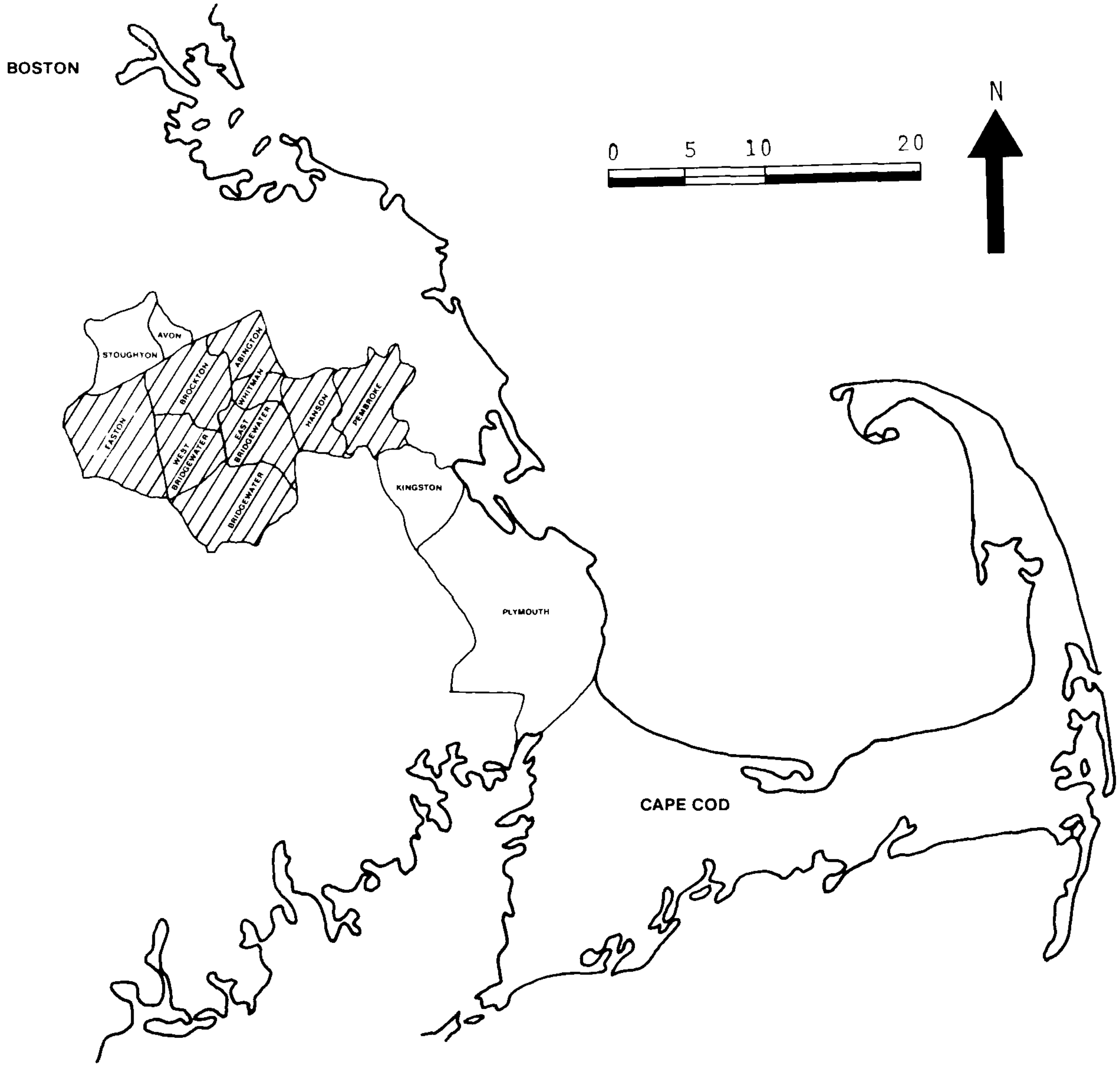

Figure 8.8 STUDY AREA FOR OLD COLONY PLANNING COUNCIL 208

limited to a few gallons per minute. Most of the area is served by on-site wastewater disposal systems (i.e. septic tanks).

Some water shortages have been experienced due to unequal distribution of supplies and water quality problems. High nitrate levels forced the closing of the largest public supply well in Bridgewater in early 1975. Other supply wells had high concentrations of sodium, iron, and manganese.

Planning was underway for a regional sewerage facility. Public opposition centered on the questionable need for the system in view of the potential loss of recharge to the groundwater, stimulus for increased water use and possible contamination of the sand and gravel aquifer from the sewer interceptor. There was also doubt about whether the septic tanks were a leading cause of the nitrate pollution in the area's groundwaters. Other possible sources of contamination included cranberry bogs, other agricultural land, and landfills.

The 208 program (which has now evolved into WQM planning) provided a mechanism to review water supply availability and quality, to identify pollutant sources, and to evaluate the need for the sewerage facility. Outside contractors were hired to provide information on the extent of groundwater aquifers, location of recharge areas, and surface water quality. The Old Colony Planning Council compiled data on water use, land uses, and groundwater quality. Legal and institutional aspects were investigated for controlling pollutant sources. The conclusion reached by the Council was that "existing laws were sufficient for control of both point and nonpoint sources and both surface and groundwater pollution, but that the problem was one of will and ability to enforce the laws" (Pojasek, 1977).

The approach taken to resolve the groundwater supply/wastewater management problem was to combine best management practices and critical area approaches. Well recharge zones were identified. Within these areas land use controls would be used to limit fertilizers and pesticides on agricultural land, to eliminate siting of landfills and salt storage piles in the recharge zones, and to maintain a buffer zone of about 10 feet between the bottom of sand and gravel quarries and the water table. Study of the nitrate levels indicated that septic tanks could be used if residential zoning was at least a half acre per single family dwelling. This approach emphasizes local ordinances although the existence of the 208 plan may encourage cooperation among the state agencies and nearby towns.

Clearly, water supply/wastewater management coordination was accomplished in this case. However, the major thrust of the 208 study toward water supply protection was considered borderline since PL 92-500 language and EPA guidance emphasized other topics such as urban and agricultural runoff. However, the Old Colony Planning Council really had no choice; no water quality plan could have achieved public credibility without emphasizing a coordinated solution of the groundwater protection and wastewater management problems.

b. Spokane 208 Aquifer Study

A larger-scale example of water supply/wastewater management coordination is the Spokane 208 Study of the Spokane Valley-Rathdrum Prairie Aquifer (see Figure 8.9). This 208 study was totally focused on characterizing threats to aquifer water quality and developing of a program to protect aquifer quality for drinking purposes.

The aquifer is very extensive, with a recharge area of approximately 350 square miles and a "streamflow source zone" of about 5,000 square miles which contributes recharge water through runoff and subsequent percolation. It consists of unconsolidated glacial deposits which have a high capacity to store and transmit water and to do so in large quantities. The aquifer is the principal source of drinking water for approximately 338,000 people and it is considered vulnerable to contamination, primarily because the glaciated soils are so highly permeable. There is evidence of localized contamination from industrial sources and septic tanks (Costle, 1978). The aquifer was recently designated as a "Sole Source Aquifer" under 1425(e) of the Safe Drinking Water Act.

The 208 study has been organized into two major phases:

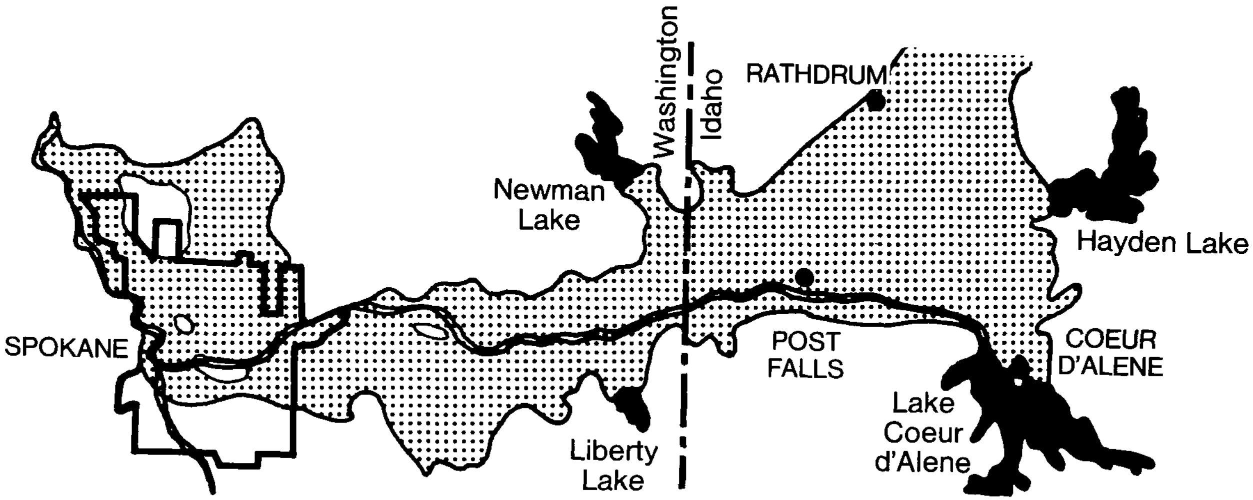

Figure 8.9 EXTENT OF SPOKANE VALLEY - RATHDRUM PRAIRIE AQUIFER

- A Cause/Effect Report on Aquifer Water Quality. This report has been developed based on extensive water sampling, review of earlier studies and analysis of land use and development activities. It has concluded that, although aquifer water quality is consistently within drinking water standards, there are variations in quality which are indicative of the land uses. These include higher concentrations of dissolved solids as one progresses downstream in the aquifer or approaches the periphery and concentration variations with depth. Spokane River waters were also found to interact with the aquifer and influence its water quality. Continuing development will continue to degrade the aquifer unless mitigating measures are implemented. The report concludes that the aquifer is particularly vulnerable to contamination by waste disposal or spills and that use of hazardous and toxic substances, even in small amounts, are a special risk (Esvelt, 1978).

- A Management Program to Protect the Aquifer. This program of controls is in the final stages of development and approval and is expected to specifically address (Spokane, County of, 1979):

  - Spills and transport of toxic and hazardous materials.
  - Industrial waste disposal practices.
  - Solid waste disposal practices.
  - Control and reclamation of pits such as from gravel mining.
  - Sanitary wastewater handling, treatment and disposal.
  - Development impacts on stormwater runoff, percolation and potential contaminants.

Again, in this example, local interest and initiative was able to give the 208 program a strong orientation toward protection of a drinking water source. The effectiveness and the practicality of the management program developed and the degree to which it is implemented will, of course, be the true test on whether water supply/wastewater management coordination is actually accomplished.

c. Twin Cities (Minnesota) Level B

Through the Upper Mississippi River Basin Commission (1978) a Level B study has been conducted of the seven county, 3,000 square mile metropolitan area including and surrounding Minneapolis and St. Paul. A water supply/wastewater management issue addressed in the study dealt with the impacts of extreme low flows in the Mississippi River, including:

- Inadequate cooling water for power generation.
- Inadequate flow to operate navigation locks.
- Shortage of water to meet peak municipal demands.
- Deterioration of water quality in Mississippi River Pool No. 2.

At the seven-day, once-in-ten-year low flow, the Mississippi River provides adequate water to meet all of the needs -- about 1400 mgd. As Figure 8.10 illustrates, water quality standards for dissolved oxygen (DO) will just be maintained at such flows assuming that planned wastewater treatment facilities are constructed.

At lower flows, however, the above impacts begin to be felt and, for example, during the 30-day, once-in-100-year low flow (about 300 mgd) they would be critical. For example, combined Minneapolis and St. Paul water supply withdrawals are projected to be about 380 mgd. In addition, 225 mgd are needed in the river to operate navigation locks. Two of the local power plants would have less than 50 percent of the needed cooling water available to them. And water quality would deteriorate markedly.

These impacts would be lessened by augmentation of extreme low flows. Several schemes to provide additional water under such circumstances were identified and some were eliminated; e.g. diversions from Lake Superior or Lake St. Croix were shown to be impractical. Other possibilities appeared to have more promise; these include operation of the existing, very large headwater reservoirs to supplement low flows or use of off-stream reservoirs. The resolution of the issue required more detailed information than the Level B study could provide, thus it was recommended that a Level C study be conducted to provide firm solutions.

Again, the true test of whether this coordination effort was effective, will be determined by future action or inaction on the

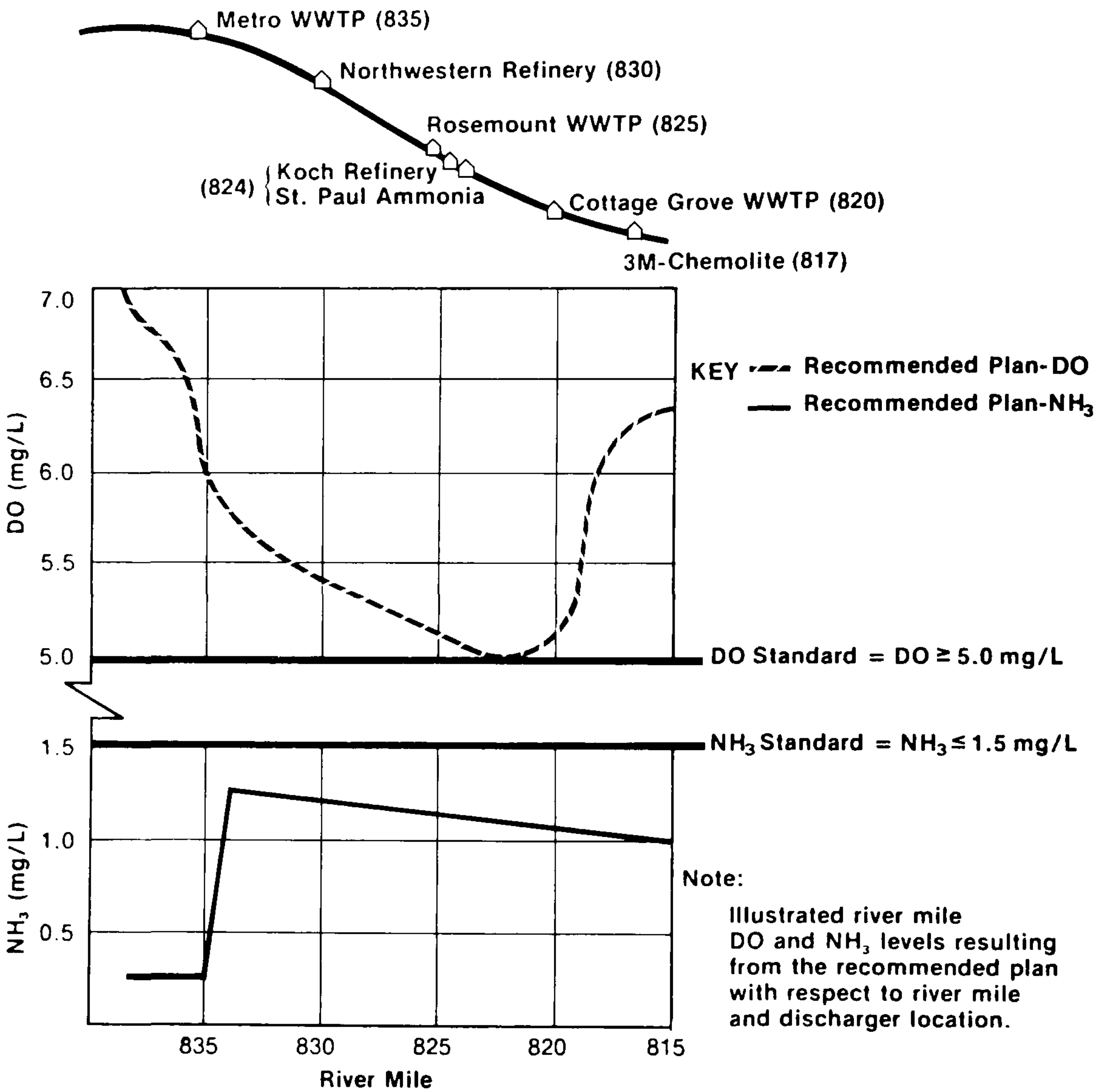

Figure 8.10 WATER QUALITY IN THE MISSISSIPPI RIVER BELOW MINNEAPOLIS-SAINT PAUL ASSUMING 7-DAY, 10-YEAR LOW FLOW AND COMPLETION OF PLANNED WASTEWATER FACILITIES

recommendation. The Level C study was scheduled for the period 1980 to 1982; therefore the test will occur soon.

3. Evaluation

The foregoing descriptions and examples of WQM and Level B planning give an impression of how water supply/wastewater coordination might occur within present mechanisms. Clearly, it can be made to occur through either program if the problem is serious or urgent and if local agencies or the public push hard enough. Further evaluation provides some additional insight.

A positive aspect of EPA's Water Quality Management program is its theme of a strong partnership with state and areawide agencies. The public workshops (see Chapter VII) provided evidence that this theme is appreciated on the state and local level and that many people believe WQM can evolve into a workable and effective program for achieving a reasonable combination of national water quality goals and local objectives. There are also weaker aspects to the program, however:

- The scope of WQM is limited in ways which often prevent water supply/wastewater management coordination. For example, the legislation and regulations are very strongly oriented toward the "fishability/swimmability" goal of the Clean Water Act and toward point and nonpoint pollution sources. Use for drinking water does receive consideration through water quality standards. However, relationships between water quantity and water quality do not receive strong emphasis, nor do the interactions between wastewater management activities and water supply activities. Thus, coordination issues may be overlooked.

- State and local agencies are sometimes reluctant to take needed control actions. There are at least two dominant reasons for this:

    - When locals adopt WQM recommendations and commit themselves to implementing them in an "EPA Plan," they feel like they are giving up control. There is a tendency to resist this and thus to make recommendations as weak as possible.

    - In addition, strong actions usually require funding, and state and local agencies are hesitant to commit themselves to implementing a program they do not believe they can afford and for which they do not see other funding.

. Unstable and decreasing Federal funding has made circumstances more difficult in terms of both planning and implementation. Planning efforts are more narrowly defined to meet budget constraints making coordination a less likely topic and the plans themselves are more bland, anticipating the absence of implementation funds. In addition the funding crunch threatens the progress made in building a strong EPA/state partnership to conduct ongoing water quality planning and implementation on a continuing basis.

With WRC's Level B planning, the most positive aspect is the broad range of topics it can address, particularly interactions between functional areas (e.g., water supply and wastewater management) and agencies (e.g., state water resource and water quality agencies). This is a prime opportunity to accomplish coordination but, again, there are difficulties:

. With a scope that is so broad, Level B studies tend to become all encompassing and unmanageable. A Level B study has broad authority to address water and related land resource problems and is supposed to integrate functional areas and coordinate agencies. However, it does not need to do everything in a single, one-year study. Instead it could focus on a few important interaction/coordination problems. The WRC (1976) has begun to address this problem by developing draft guidance which has the primary theme of narrowing down the study -- of focusing on the important issues.

. Level B planning is regarded as a one-time study effort. This increases the tendency to try to do everything -- to have the plan cover all functional areas and all the agencies. This can mean that everything gets discussed but no problems get solved.

. Implementation is particularly difficult. Level B study teams are organized for the duration of the study and then disbanded. Although the participating agencies may follow through on particular recommendations, there is no commitment to do so. The WRC has recently initiated a review of eight Level B studies to examine what changes they have implemented and whether specific changes can be identified which will make Level B implementation more effective.

- Funding has been limited. Although Congress mandated completion of Level B studies for the whole country by Janaury 1, 1980 (Section 209, PL 92-500), only a few studies have been started each year and complete coverage is far from being achieved.

D. Major Findings

This chapter has reviewed EPA's Construction Grants Program and broader planning through EPA's Water Quality Management Program and WRC's Level B Planning Program. As a result of this review, the following is ascertained:

- A number of mechanisms to encourage or effect coordination are contained within the current Construction Grants Program. These include means to identify potential opportunities and to implement solutions through grant funded facilities.

- Recognition of opportunities most often occurs in response to locally recognized needs rather than to imposed conditions or requirements.

- Constraints to achieving coordination through the Construction Grants Program with respect to a common water unit may include: (1) late recognition of impacts on present or future water supplies, (2) difficulty in determining water quality/discharge requirements based on water supply impacts within facility planning, (3) lack of funding flexibility to adequately consider alternatives which include water supply components.

- Constraints to achieving coordination through the Construction Grants Program with respect to planning for overlapping service areas include: (1) separate planning entities, (2) timing may not coincide, and different assumption on (3) population growth or (4) land use planning may be used.

- A limitation to achieving coordination through the Construction Grants Program with respect to wastewater reuse is restriction of funding largely to those projects addressing a water pollution control need.

- Constraints to achieving coordination through the Construction Grants Program with respect to water conservation include: (1) the mutual independence of water supply and wastewater agencies; (2) current facility planning requirements are not positive incentives toward implementing strong water conservation measures.

- Broader water quality or water resources planning (rather than wastewater facility planning) is often the suitable mechanism for addressing specific problems in water supply/wastewater management coordination.

- EPA's Water Quality Management Program is one mechanism which can be effective; it has broad state and local support because it is responsive to state and local concerns. The new WQM regulations place renewed emphasis on WQM's ongoing nature and on implementation. Its primary remaining weaknesses are:

  - A scope which is strongly oriented toward water quality and may miss important water supply or water quantity factors which interact with water quality.

  - Unstable and low funding which makes development and maintenance of the continuing EPA/state partnership very difficult.

- WRC's Level B program is another mechanism which can be effective; it has a broad authority to identify and resolve coordination and integration problems. Its primary weaknesses are:

  - Study teams represent many agencies. As a result there is a tendency to address each agency's interests and include its projects in the plan. A more effective Level B plan would focus on ways to resolve a few important issues.

  - There is too little commitment to implementation of Level B study results.

The WRC is now addressing both of these weaknesses.

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Chapter IX

MUNICIPAL WATER CONSERVATION AND REUSE

A. Introduction

Water conservation is a concept with a range of meanings, some very broad and others much more specific. For example, a broad definition might be stated in terms of the wise development, protection, and use of water resources, including (1) development of dams and reservoirs to capture, control, and supply water to the maximum extent feasible, (2) development and protection of groundwater sources so their future utility is not impaired, and (3) use (and reuse) of available supplies in an intensive and efficient manner. An even broader definition might explicitly recognize the many other resources involved or affected by water supply and use (e.g., energy, manpower, capital, water quality), and the viability of impacted natural ecosystems.

In contrast, a very narrow definition could be adopted; for example, by focusing on the per capita daily amount of water required by residential users for toilet flushing or showers and their associated expenditures for water and conservation devices. This has been the tendency in many recent studies.

The objectives of this chapter are to synthesize information on the broad advantages and disadvantages of municipal conservation and reuse and to highlight its implications for national policy. These objectives point toward specific definitions for the purposes of this chapter:

- Water conservation means reducing (or slowing the rate of growth of) per capita demand for municipal water supply.

- Reuse means use of municipal effluents for some nonpotable purpose.

In embarking on such a broad discussion of beneficial and adverse impacts and in trying to establish a national overview, it is important to remember that the consequences of conservation and reuse will be quite variable depending on local circumstances. For example:

- Conservation in San Francisco is different from Cincinnati. San Francisco's water system withdraws from high mountain sources and wastewater discharge is to the bay and ocean. Consequently, reduced municipal use may augment mountain streamflows, improve water quality, provide water for other uses (perhaps several cycles of use), or allow increased groundwater recharge in the San Joaquin Valley. In contrast, the Cincinnati system withdraws water from the Ohio River and discharges wastewater back to the river some distance downstream. In this case municipal conservation would provide insignificant advantages in terms of in-stream flows or other supplies and only slight improvements in water quality.

- Reuse in Texas is different from in Baltimore. In Texas reuse often occurs indirectly and naturally; when municipal effluent is discharged to a stream, it is frequently diverted a short distance downstream for agricultural irrigation. If direct reuse were implemented, for example by constructing a pipeline to some other nearby farm, it would involve an additional expense for the pipeline, it might eliminate in-stream flow and water quality, and it would interfere with the indirect reuse downstream. In contrast, Baltimore's wastewater is directly reused for cooling Bethlehem Steel. In this case no indirect use was being made of Baltimore's wastewater (it was discharged to Chesapeake Bay) and the wastewater was a valued, higher quality replacement for the saline bay and groundwater which Bethlehem had been using.

Thus although emphasis will be placed on "typical" cases and on synthesizing an aggregate national picture, the existence of significant local and regional variations must be constantly kept in mind.

B. Municipal Water Conservation

This discussion of possibilities for slowing the rate of growth or reducing the per capita water demand experienced by community (municipal) water systems has three main emphases:

- Consideration of water demand in contrast to the traditional primary concern with supply.
- Consideration of all community uses--residential, commercial, public, community-supplied industrial, and leakage.
- Consideration of all benefits and costs--economic, environmental, energy, etc.

1. Present Status

a. Federal Activities

In light of the increasing cost of water supply projects and the severe drought experienced in the Western U.S. during the summers of 1976 and 1977, water conservation is very much on people's minds. Responding to and intensifying this public interest is President Carter's Water Policy Message of June, 1978, which identifies water conservation as warranting national emphasis. Although the overall policy is much broader, several specific initiatives bear directly on municipal water conservation:

- Directives have been sent to Federal agencies to:
  - Make appropriate community water conservation measures a condition of water supply and wastewater treatment grant and loan programs.
  - Integrate water conservation requirements into housing assistance programs.
  - Provide technical assistance on how to conserve water through existing programs.
  - Require development of water conservation programs as a condition to storage or delivery of municipal or industrial water supplies from Federal projects.
  - Require establishment of water conservation goals and standards in Federal buildings and facilities.
- Draft legislation is being prepared to allow States to implement conservation pricing for municipal and industrial water supplies from Federal projects.

- Draft legislation has been prepared to provide $25 million matching funds to states to implement water conservation technical assistance programs.

- A task force of Federal, State, and local officials has been created to continue addressing water-related problems, one being possible assistance to rehabilitate leaky urban water systems.

Several implementation task forces have been established to respond to these initiatives under direction from the Secretary of the Interior. Those of most relevance to this discussion are:

- Task Force 11--Water Conservation Provisions in Grant and Loan Programs for Water Supply and Wastewater Treatment.

- Task Force 9--Water Conservation in Housing Assistance Programs.

- Task Force 10--Water Conservation in Federal Facilities (operated by GSA).

- Task Force 6a--Water Conservation.

- Task Force 7--Conservation Pricing.

Since the work of these task forces is ongoing at the time of this writing, final results cannot yet be reported. However, interim task force reports are available.

These interim reports provide the following highlights of the ongoing and intended Federal programs which are most relevant to municipal water conservation as defined for the present discussion:

- As a part of EPA's wastewater Construction Grant's Program, §204(a)(5) of the Clean Water Act requires that approvable amounts of reserve capacity take into account "efforts to reduce the total flow of sewage and unnecessary water consumption." In response, the Construction Grant Program's cost-effectiveness guidelines require evaluation of flow-reduction measures such as plastic toilet dams and low flow showerheads; changes in laws, ordinances, or plumbing codes requiring installation of water-saving devices in future habitations; and water pricing changes. The grantee must develop a recommended flow reduction program featuring a public information program plus cost-effective measures for which the grantee has implementation authority or can obtain cooperation from an entity with such authority. Exempted from these requirements are those communities with a population less than 10,000 or with average daily base flows, excluding infiltration/inflow and industrial flows, for treatment works design of less than 70 gallons per capita per day or with ongoing flow reduction programs.

The above legislative provision was part of the 1977 amendments and the new guidelines were effective June 26, 1978; it is therefore too early to assess their effect on municipal water conservation. EPA does intend to prepare a "Flow Reduction Handbook" to enhance the effectiveness of this guideline.

- Another part of EPA's Construction Grants Program is oriented toward industrial pretreatment and user charges based on the volume and strength of wastewaters discharged to publicly-owned systems. Where such industries are supplied by community water systems, these provisions provide significant incentives for water use reduction and for in-plant recirculation, both of which will reduce the industrial portion of community water demand.

- As part of EPA's Water Quality Management Planning Program, in response to §§ 106, 205(g), 208, and 303(e) of the Clean Water Act, new comprehensive regulations have recently been published in which water conservation is explicitly recognized:

    - They require consideration of water conservation needs related to water quality in the water quality assessment process (§ 35.1511-1(a)).

    - They suggest proposal of municipal water conservation programs in the context of defining municipal and industrial wastewater facility needs (§ 35.1521-4(d)).

    - They suggest that the plan identify (where appropriate in light of funding and priorities) water conservation needs and practices to achieve and maintain water quality standards and to ensure efficiency in municipal wastewater treatment (§ 35.1521-4(h)).

These regulations became effective May 23, 1979; thus it is too early to assess their contribution toward municipal water conservation.

. As part of the EPA's Research and Demonstration Program and in response to §104(o) of the Clean Water Act, investigations are conducted into devices, systems, incentives, pricing policy and other methods for reducing wastewater flow. Results are communicated to Congress as part of the reports under §516(a). In light of funding limitations and the higher priority placed on health effects research, the progress made under this 1972 provision has been limited.

. As part of the Farmers Home Administration Grant and Loan Program for Water and Waste Disposal Systems for Rural Communities, water meters have recently been required for each connection on water facilities financed under FmHA programs except on specific variance granted by the State FmHA Director.

. As part of the Economic Development Administration grant programs which can finance water and wastewater systems, metered water systems are now required under several programs; it is intended to extend this requirement to all water and sewer projects and to allow water metering facilities as an eligible project cost.

. Several programs under the Department of Housing and Urban Development provide funds which can be used in water and wastewater construction or planning. It is HUD's interpretation of its legislative authority that primary emphasis in these programs is to provide discretion to local agencies and thus, that explicit encouragement of water conservation would not be appropriate.

. Other HUD programs assist with housing development and, as part of these programs, Task Force 9 (1979) has identified several water conservation actions (e.g., low flow showerheads) which HUD intends to implement through such means as their Minimum Property Standards. Other actions have been identified for further study and potential future implementation.

- The General Services Administration several years ago adopted the 3.5 gallons (or less) per flush water-use standard for water-saving toilets in new GSA buildings. Since that time, this standard has become the rule of thumb commonly accepted in other water conservation programs. As reported by Task Force 10 (1978) GSA is continuing to aggressively identify practical water conservation opportunities.

- The Office of Water Research and Technology, as part of its general water research program, has established water conservation as a priority area with FY79 funds of $750,000. Although agricultural and other water conservation research will receive support from these funds, it is expected that some projects will be oriented toward the socio-economic, institutional and legal aspects of municipal conservation. In addition, OWRT has supported important research projects on municipal water conservation through the water resources research institutes located at universities in each state.

In summary, Federal programs relevant to municipal water conservation are now in a state of flux. Most of the significant actions are either recent or imminent and it is difficult to assess their effectiveness. However, it appears that in many cases effectiveness will be limited due to agency commitment to its primary mission, its priorities in light of that mission, and funding limitations.

b. <u>State and Local Initiatives</u>

Several state and local governments have acted to encourage or require water savings in municipal settings. This is particularly true in the west as a result of the recent drought. For example,

- California now requires installation of water conserving toilets in new construction and authorizes municipal water districts to require stronger conservation measures as a prerequisite to new connections. As an energy conservation measure, low flow showerheads and faucets are also required in all new installations.

- The Goleta County Water District in Santa Barbara County, California, requires installation of water conserving fixtures for all toilets, faucets, and other water using devices in new and replacement construction and has other stringent rules which promote water conservation.

- The Washington Suburban Sanitary Commission has revised local plumbing codes to require pressure-reducing valves, water saving toilets, low-flow showerheads and maximum allowable faucet flows in new and replacement construction. This has been combined with maintenance of a list of approved water-saving devices and an extensive public education and retrofitting program. It is widely recognized as one of the most effective programs in the county. The program was motivated by the limited capacity of water and wastewater systems, difficulties in expansion, and consequent impediments to new building.

These are simply examples of the many state and local conservation initiatives which occur throughout the country. Although many are considered effective, they have usually been precipitated by local crises such as drought or rapid community growth and limited water and wastewater capacity. In most cases their effectiveness on long term water use remains to be established.

c. Fixture Manufacturers

With the increased interest in municipal water conservation over the past four to five years, most leading manufacturers have developed and made available a line of water-saving fixtures. This has been a necessity for economic survival given such initiatives as the GSA low-flush toilet standard and the California law adopting the same standard for new construction. There was some apparent reluctance on the part of manufacturers to design fixtures for lower water use; some attempted minor modifications on conventional fixtures instead. However, the National Association of Plumbing Manufacturers is now revising its standards. Still, there are no readily accessible data on what proportion of present fixtures manufactured can be classified as "water saving".

d. Summary Status

Municipal water conservation is very much on a threshold. There has been adequate interest and experience to recognize its advantages in some circumstances, but application has been limited. If long term conservation has widespread advantages, they have not yet been made obvious. This could occur during the next several years.

2. Amounts of Municipal Water Use

The national average amount of water supplied by community systems in 1975 was about 190 gallons per capita-day. Of this, about 41 gpcd were supplied to industries and are classified as "manufacturing" use in the Second Assessment (WRC, 1978a). The remainder, about 149 gpcd, is traditionally called the "domestic and commercial" portion of municipal water demand (WRC, 1978b).

A more detailed breakdown of the 1975 municipal uses is provided in Table IX-1. As indicated, the "domestic" portion (118 gpcd) is

Table IX-1

MUNICIPAL WATER USES IN 1975

(approximate national averages)

Use Category	gpcd	
Commercial	31	
Residential In-House	65	118 "Domestic"
Residential Outside	28	
Public (Fires, School, etc.)	10	
Losses (10% of Domestic & Commercial)	15	
Total "Domestic and Commercial"	149	
Industrial (Municipally Supplied)	41	
Total Municipal Use	190	

Source: WRC (1978 a & b)

defined to include public usage for schools, parks, public buildings, fires, etc., and system leakage as well as residential uses. Although good data are not available as a basis for all these numbers, they are drawn heavily from WRC's Second Assessment and approximate several estimates presented in the literature.

Figure 9.1 synthesizes data on past domestic and commercial per capita water use and displays the projections adopted by the WRC in its First and Second National Water Assessments. Data points are from the USGS series of reports on water use (e.g., Murray and Reeves, 1975) and from the 1965 and 1975 tabulations presented by the two WRC assessments. The differences between the USGS and WRC data points in 1965 and 1975 provide an indication of data accuracy. In addition, it is noted that some assumptions and calculations were required to remove the industrial portion of demand from the USGS data. Given these qualifications, the following is observed:

- Available data indicate significant increases in per capita demand, especially for the period 1965-1975.

- Both WRC projections assume these increases will stop, an assumption which can be questioned based on its lack of success in the WRC's First Assessment.

- Inconsistencies in the data and projections cannot be easily resolved with available information; for example, the projection of constant per capita use for the future assumes that the tendency toward increases due to water using appliances (garbage disposals, dish washers, etc.) will be counterbalanced by some conservation program, but the magnitude of these two forces is not indicated.

- In any case, a major conservation effort may be required simply to stabilize per capita demand.

3. Potential for Municipal Conservation

It is estimated that average national per capita municipal water demand could be reduced by 20 to 40 percent, and perhaps more, without making significant changes in lifestyles and without adopting advanced technology. Furthermore, these results could be realized with net economic savings and significant benefits in terms of energy savings and environmental quality.

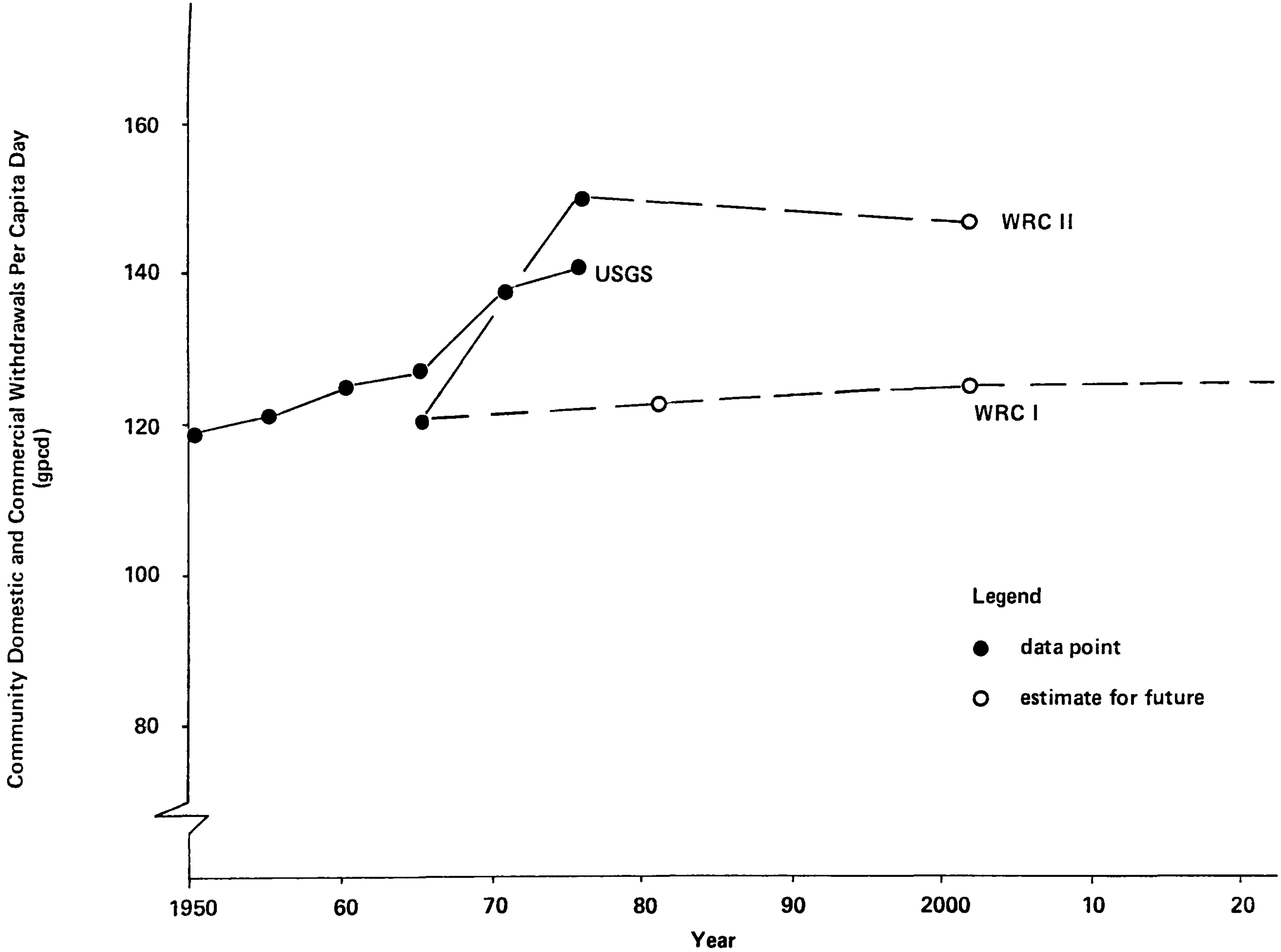

Figure 9.1 AVERAGE U.S. COMMUNITY DOMESTIC AND COMMERCIAL WITHDRAWALS PER CAPITA

Table IX-2 synthesizes the above estimates of overall municipal conservation potential based on the best estimates presently available (see Appendix A for more detail). Even though the ranges used do allow considerable room for uncertainty, some estimates require further research to provide improved data. These results should be interpreted cautiously as indicated by the following observations:

- Is is clear that per capita municipal water use will not decrease by 20-40 percent overnight, or even over a couple of years. These estimates are of long-term potential savings: for example, they assume that present clothes washers and dishwashers eventually wear out and are replaced with water-efficient models. Thus it may take 15 to 30 years to implement all the changes visualized.

- Potential is based on technical and economic feasibility of relatively simple, passive devices and actions using present research results and assuming universal implementation. Clearly, further research may alter these estimates and full implementation may never be realized.

- Present day per capita use is a baseline use for comparison. This does not mean that national municipal water use, average per capita use, or even the amount of water sold by any specific utility will ever be less than today if conservation is implemented. The long time frame and regional differences in implementation may mean that:

  - per capita savings simply offset per capita increases occurring over time due to other factors (e.g., more dishwashers, more landscape watering, or just a higher standard of living),

  - decreases in per capita use simply offset overall increases in water use due to population growth, or

  - less savings are achieved in some areas (e.g., water rich areas) than in other areas where conservation is more intensively applied.

- Each conservation action has been found economically feasible under some part of the conditions considered (e.g., new construction, high water savings estimate, low cost estimate).

Table IX-2

MUNICIPAL WATER CONSERVATION POTENTIAL

Use	Percent Reduction in Each Type of Per Capita Demand	Basis
Residential In-House	25-45	Water saving plumbing and appliances, pressure reducers, meters, and avoid waste.[a]
Residential Outside	30-50	Meters, pressure reducers, drought resistant vegetation, avoid overwatering, and avoid waste.[a]
Commercial	20-40	Water saving devices analogous to residences, self-closing faucets, and avoid waste.[b]
Public	20-40	Same reasoning as commercial.[b]
Industrial	20-40	Wastewater treatment and pre-treatment requirements, waste-water user changes, changing water supply rate structures.[b]
Losses	20-40	Experience in Oakland California (Laverty, 1979) and anticipated leak repair in older systems.[b]
Reduction in Total Municipal Use:	23-43 percent	
but say	20-40 percent to round off and be conservative	

a. See Appendix A for detailed support of this estimate

b. Potential water savings for these categories have not been analyzed on a comprehensive basis in the technical literature. Estimates are the result of this author's extrapolation of the residential estimates and of the limited technical information now available.

- Many of the actions are very attractive even with low estimates of water savings and high estimates of conservation device cost.

More detail is provided in Appendix A on the basis for these estimates of conservation potential. The associated energy savings and monetary benefits and cost are also explored to provide a preliminary assessment of cost-effectiveness for each action.

4. Realistic Conservation

Although the preceding section is thought to present a reasonable estimated range of the overall potential for water savings from municipal conservation, the fact is that full potential is not likely to be achieved. Therefore, as a basis for further discussion, a less ambitious "realistic" conservation scenario is defined in this section. It incorporates the following assumptions:

- Only simple, passive conservation measures are employed (e.g., not even dual cycle toilets are recognized).
- No change in lifestyle or habits is assumed; this means that the same length of time is spent in showers and that no conservation is achieved through education programs oriented toward avoiding waste.
- The low estimate from the range of potential water savings is used in each case (see Appendix A and Table IX-2).
- The high estimate from the range of potential conservation costs is used in each case (see Appendix A).
- A long implementation/transition period is assumed (approximately 15 years).
- As a result of more intensive implementation in some areas and less in others, this gives an approximate estimate of achievements nationwide.

The following program requirements are assumed to be part of the "realistic" scenario:

- In new construction the following are required:
  - 3.5 gallon/flush toilets,
  - 3 gallon/minute limit on shower flow,

- 1.5 gallon/minute limit on faucet flow,
- Pressure reducing valves--50 PSI (maximum),
- Water meters.

. In present buildings:

- Retrofitting as above is required except for meters,
- Variances are available based on practicalities or economics.

. On appliances, the following are required and result in the realization of modest water savings, primarily by raising the awareness of manufacturers:

- Water use labeling,
- Energy use labeling (including hot water energy).

. For nonresidential uses, the above requirements and other moderate actions (e.g., water supply leak detection, car wash recirculation, etc.) achieve 20 percent water savings.

These assumptions, paired with the water savings and cost estimates from Appendix A imply an overall water savings of 20 percent as shown by the resulting water uses listed in Table IX-3. Even with the above assumptions, (e.g. low saving and high cost), the B/C ratios of the individual actions included range from 1.0 to 6.6.

5. <u>Conservation Impacts</u>

To better understand the opportunities associated with conservation, it is helpful to analyze the "realistic" conservation scenario from several points of view. Four viewpoints are discussed:

. The residential user--a typical family of four.

. The community.

. The nation.

. Water quality agencies.

Table IX-3

WATER USE RESULTS WITH REALISTIC CONSERVATION
(gpcd)

Location/Activity	Without Conservation	With Conservation	Hot Water Saved
Toilet	25	17	0
Bath/Shower	20	17	1.5
Lavatory Sink	3	2.5	0.2
Laundry	9	7	1.0
Dishwashing	4	3.5	0.3
Cooking/Drinking	4	3	0.3
Outside	28	24	0
Total Residential	93	74	3.3
Other Municipal	97	78[a]	1.7[b]
Total Municipal	190	152	5

a. Assumes 20% savings

b. Assumes 10% of water saved

Table IX-4 summarizes the impacts seen from these viewpoints.

The 3 percent decrease in national energy imports and corresponding 7 percent decrease in balance of trade deficit deserve special note from the broad national viewpoint; all the small contributions possible are needed to overcome these vexing national problems. Of special importance from EPA's viewpoint are the water quality impacts, particularly the potential for:

- Decreases (or smaller increases) in groundwater withdrawals in regions of overdraft with a corresponding decrease in such problems as salt water intrusion.
- Decreases (or smaller increases) in withdrawals from groundwater which interact with streamflows so that this groundwater is more available to maintain summertime and drought period in-stream flows with associated improvements in water quality.
- Decreases (or smaller increases) in high mountains and upstream surface water withdrawals so that these waters are also more available for maintaining in-stream flows, water quality, and aquatic life during low flow periods.
- Decreasing the amount of money needed for reserve capacity and future expansion of wastewater treatment facilities.

Other specific highlights of the impact analyses are:

- For a typical family of four, which implements the conservation program, the net savings would be about \$16 per year and the benefit to cost ratio would be about 2.7 to 1.
- Even in a community with no population growth and 90 percent of its water supply costs fixed, the savings in water heating and residual water supply costs are adequate to provide net benefits for the family (i.e., B/C ratio is greater than one).
- Especially in a community which is growing and reaching the capacity limits of its present water supply and wastewater facilities, municipal water conservation is extremely advantageous. (A hypothetical example showed a benefit to cost ratio 7.2).

Table IX-4

MAJOR FAMILY COMMUNITY AND NATIONAL IMPACTS OF REALISTIC MUNICIPAL CONSERVATION

	Family of Four	Community	Nation
Water Use	-20% (-76 gpd)	-20% (Delay Expansion)	-2% Withdrawals (-7 bgd)
Energy Use	-2% Total (-1.3 barrels/year)	-15% WS & WW Utilities (20 BTU/gallon)	-3% Imports ($-90x10^6$ barrels/year)
Money	-7% Water-Related Expenses (-$16/year, net)	-13% Net Imports for Water and Wastewater (-$8/capita- year)	-7% Net Imports ($2 billion/year) Less need or more rapid progress for Wastewater Construction Grants ($150 million/ year)[a]
Water Quality	Improved nearby . recreation . fish and wildlife	Less use of water sources providing better buffer for quality: . groundwater savings accumulate all year . surface waters are less needed and more easily augmented during low flows . improved stream resource, especially in areas immediately upstream from community	Improve water quality especially in crucial regions: . groundwater overdraft with associated quality problems . surface water problems where flows are frequently below those needed to maintain water quality standards

a. Tiemens and Graham, 1978

Source: Calculations by author as provided in Appendix B

- In looking at water conservation impacts on a hypothetical community's balance-of-trade, it was found that less money would flow out of the community; the smaller payments for energy and equipment more than make up for the decreased size of Federal wastewater construction grants.

- Although the 20 percent decrease in municipal water supply withdrawals is only a 2 percent decrease in overall national withdrawals, the difference is significant and would be very welcome in regions where the alternative is groundwater overdraft, elimination of some other beneficial use, or complete depletion of streamflow.

Additional details on the analysis of impacts from the "realistic" conservation scenario are provided in Appendix B.

The striking factor about municipal water conservation impacts is that they are so overwhelmingly positive from most viewpoints. The economic costs are recoverable by severalfold and there are important energy and environmental benefits besides. This is very rare in projects or actions considered today.

6. Implementation Mechanisms

Assuming that water conservation is attractive to a community as a result of analyses similar to the foregoing, six generic types of techniques are available to imlement a municipal water conservation program. These include:

- Plumbing Code Modifications. This is probably the most effective mechanism to achieve long term implementation of water conservation measures. For example, if the passive conservation measures identified for the "realistic" scenario are required in all new construction and, as appropriate, in extensive remodelling, one would expect full implementation over a period of 30 to 50 years. Some major code changes have already been made (e.g., in the Washington, D.C. area and in California), but most have been in localized areas responding to specific growth or water shortage problems. Many localities adopt the "Uniform Plumbing Code" as the local standard. Although changes in this national code are being discussed, they are not yet a reality nor can they be expected without further definitive research results to better establish practical design standards.

- Pricing. There is a trend toward either a fixed price per gallon or an increasing price per gallon with increasing water demand. These pricing structures, when carefully developed and applied to the various classes of use, can be an equitable and effective incentive to avoid excessive water use or waste. Such a price structure is almost essential if it is hoped to have the water user be aware of potential water savings and to actively participate in conservation. In general, however, price alone is not an adequate mechanism to implement water conservation in a municipal setting.

- Metering. During the past 20 years most community water systems have required installation of water meters, at least on new connections. Although these meters require significant expenditures for purchase, installation, maintenance, reading and billing, they are crucial to the type of pricing structure mentioned above and to any real awareness of amounts of water used. Unfortunately, meters are very expensive to install in existing, unmetered residential connections in comparison with the value of water and other savings. However, equity considerations may warrant such installations anyway, especially where significant outside water use occurs.

- Education. Public information campaigns can achieve significant conservation results, especially in emergency situations such as drought. For long-term conservation, they are probably more valuable to simply create consumer awareness of meter readings, rate structures, and the tangible consumer advantages of conservation. The Washington Suburban Sanitary Commission provides a prime example of conducting an effective education program for implementing long-term conservation.

- Retrofit Programs. Modification of existing facilities and fixtures can be accomplished on two distinct bases: (1) voluntary modification by the property owner in response to pricing and education programs or other incentives, (2) a cooperative program between the utility and property owners where needed changes are performed and checked by utility personnel or contractors. Although voluntary programs were extremely effective in the crisis atmosphere of a drought (e.g., Marin County, California), achieving anything close to full implementation in a long-term program may require onsite utility involvement in making necessary modifications.

- Incentives. Beyond the obvious incentive of water supply price structure, incentive programs for municipal water conservation are still relatively recent or are now in formative stages. Examples include the following:

  - User charges and pretreatment requirements which are part of EPA's Construction Grants Program are a significant incentive, especially in the industrial sector where they are usually applicable.

  - The flow reduction requirements, which are a condition of the construction grant in situations where wastewater flow is excessive, are also a strong conservation incentive although they may not be totally effective because of limited wastewater agency authority to implement conservation.

  - Other Federal agencies are incorporating similar incentives into their programs in response to the President's water policy as described in Section B.1.

  - Other incentives could be developed; for example, tax credits such as those now used to encourage energy conservation.

In summary, various implementation mechanisms are available. However, those to be used in a particular community should be based on the specific conservation accomplishments and time frame desired and their suitability in the local setting.

7. Impediments

Five notable impediments to implementation have surfaced based on this review of past experiences and ongoing activities and the analysis of a conservative, national-average overview of municipal conservation:

- There is a lack of clearly organized, comprehensive information on overall beneficial and adverse impacts:

  - For nationally typical situations.

  - For regional or special local circumstances.

- There is considerable uncertainty in:
  - Present water use data and patterns, especially within each consumer group.
  - Cost estimates for conservation actions.
  - The extent to which a conservation device can reduce flow and still be satisfactory and practical.
  - Water supply and wastewater expenditure patterns.
  - Marginal costs of water supply and wastewater management.
- There is considerable inertia to overcome if municipal water conservation is to be extensively implemented:
  - People and utilities would need to put effort into implementing it and a modest financial investment would be required.
  - Since water utilities have a relatively high percentage of fixed costs, conservation would have to be implemented very carefully to avoid losses of water revenues. People would probably resist conservation if they felt it would necessitate increased water rates, even if such increases were compensated for by less water use and lower water heating bills.
  - There is a tendency, from past practices, to concentrate on supplying all the water that municipal users will use rather than attempting to hold down demand; indeed, there is some incentive for utilities to encourage increases in water demand in order to raise more revenue without increasing water rates.
  - Institutional factors, such as plumbing codes, or water utility-enthusiasm for conservation, change slowly.
- The present incentives which influence municipal water conservation decisions are not completely effective in some cases and discourage conservation in others:
  - Consideration of wastewater flow reduction in cost-effectiveness analysis (as required by Construction Grants Regulations) often does not receive its deserved emphasis because the wastewater agency may not be able to implement a strong conservation program; it must often depend on cooperation from a

water supply utility which is skeptical about conservation advantages.

- The costs of municipal water supply are frequently subsidized through participation in Federal or State projects; thus the potential savings from conservation are not fully seen from a local viewpoint.

- Metering of customer use is costly, but is important for creating customer awareness of water use. Especially in existing residential areas where meters are not now used and lawn watering is heavy, the expense to install meters (and their necessity from an equity viewpoint) may prevent adoption of an effective water conservation program.

. Water law is, itself, a major impediment. It encourages excess withdrawals to establish larger water claims and then discourages any reduction in use since claims could be lost. Only when potential supplies are fully developed would the water utility begin to try accomodating growing needs through more efficient use.

8. Findings

The findings which result from this discussion can be highlighted as follows:

. Municipal water conservation is often disregarded because:

  - It is not one of the largest national uses of water.
  - Many regions have no shortage of municipal supplies.
  - It is feared that conservation will simply result in water rate increases without significant cost savings to the consumer.
  - Water utilities tend to be skeptical or, at best, lukewarm toward conservation.
  - Water conservation is actually discouraged by present situations such as water supply subsidies or the high cost of installing meters where they are not now used.

. This overlooks some major monetary advantages of conservation:

  - Energy savings.
  - Delayed expansion of water and wastewater facilities.

  - When all benefits and costs are considered, at least a moderate conservation program appears to be justified in any typical community.

  - The energy savings alone are adequate to justify a hot water conservation program in a typical non-growing, water-rich community.

- There are significant Federal advantages to implementing municipal water conservation as well:

  - Energy savings in hot water heating and in water supply and wastewater systems can result in small but welcome reductions in energy imports (90 million barrels less per year) and the balance-of-trade deficit (2 billion dollars less per year).

  - In specific locations, smaller municipal withdrawals can have significant beneficial impacts on water quality, especially in cases of groundwater overdraft or low streamflow.

  - Smaller volumes of wastewater treated to present effluent quality would mean decreased discharge of pollutants.

  - Conservation would also result in a reduced need for wastewater construction grants (by approximately 150 million dollars per year) or, alternatively, more rapid compliance with present effluent requirements and in-stream quality standards.

  - Water saved would be available to supply other off-stream uses in areas where it was not allocated to in-stream use or improvements in groundwater management.

- There are also notable impediments to conservation:

  - Lack of clear information on comprehensive advantages and disadvantages.

  - Uncertainty in numbers needed to adequately calculate impacts.

  - Inertia in local agencies and consumers.

  - The bias toward over appropriation and overuse in western water law.

- Municipal conservation is on a threshold. Its future depends on actions taken in the next few years to overcome the impediments. Actions now being implemented do not appear adequate to create real enthusiasm at the local level.

C. Reuse of Municipal Effluents

This discussion focuses on the direct reuse of municipal wastewater effluents for nonpotable purposes. The following points are emphasized to clarify the definition of terms and to distinguish this discussion from other, closely related topics:

- Examples of the direct reuse of municipal effluent (as the term is defined herein) include those for landscape and agricultural irrigation, industrial processes or cooling, recreation, and groundwater recharge.

- Direct reuse implies existence of a pipe, or some other manmade conduit, for delivering the first user's effluent to the second user or use.

- Indirect reuse, through discharge of an effluent to a stream and withdrawal downstream, is recognized to be important but is not a primary focus of this discussion (see SCS Engineers, 1979, for a discussion on this topic).

- Direct, potable reuse is not considered here because further research and demonstration is required to provide additional assurances of safety and these programs will take several years before implementation can be seriously contemplated.

- Effluent use for groundwater recharge is recognized as a special type of direct reuse -- the "direct" portion referring to its conveyance to and application through recharge facilities. It is recognized that this could also be viewed as a type of indirect reuse (through groundwater aquifers) which may involve potable supplies.

- Recycling or recirculation, in contrast to reuse, involves only one user or use; the effluent from the use is captured and redirected back into that use scheme. The Second National Assessment (WRC, 1978 a & b) and a recent study sponsored by OWRT (Culp, Wesner & Culp, 1979) address recycling with regard to the steam electric, manufacturing, and minerals water use categories.

Especially in steam electric and manufacturing industries, recycling is expected to increase dramatically. In general, it is expected that the salt content of the ultimate discharges from these sectors will have become relatively high and that they will not be extensively sought for further reuse.

. Municipal effluents are considered here to be only reusable and not recyclable. For example, where treated effluent is provided for landscape irrigation through a dual distribution system, this is a different use than general, potable municipal use, and the reuse label therefore applies.

. Again, as in the case of the conservation discussion, emphasis is placed on consideration of all relevant benefits and costs of municipal effluent reuse.

1. Present Status of Municipal Wastewater Reuse

a. Reuse Now Occurring

Total municipal wastewater discharges in the U.S. amounted to about 24 billion gallons per day in 1975 (Metcalf & Eddy, 1978). In comparison, approximately 0.7 bgd, almost all of which is municipal effluent, are directly reused in the context of 536 separate projects (Culp/Wesner/Culp, 1979). Table IX-5 summarizes the distribution of this reuse among purposes. Most of the water volume and projects are for agricultural irrigation and there are a few relatively large projects which supply industrial cooling and process waters. Although other reuse is small by comparison, it is important -- for example, 33 mgd are reused in 60 projects which are known to be for landscape irrigation.

The majority of reuse projects, accounting for the largest volume of wastewater, are located in the Southwest and South-Central Regions of the country, primarily in Arizona, California, and Texas (Culp/Wesner/Culp, 1979).

The data in Table IX-5 do not include the wastewater reuse that occurs incidentally as part of land treatment (e.g., in Muskegon County, Michigan). In land treatment systems, a portion of the wastewater is reused even in humid climates. In arid climates, it is often

Table IX-5

PRESENT REUSE OF MUNICIPAL WASTEWATER

Use	Percent of Wastewater		Percent of Projects	
Irrigation		62		88
Agricultural	29		28	
Landscape	5		11	
Not Specified	28		49	
Industrial		31.5		5
Process	9.5			
Cooling	21			
Boiler Feed	1			
Groundwater Recharge		5		2
Other (Recreation, etc.)		1.5		5
		100.0%		100.0%
	≅	0.7 bgd	=	536 projects
	≅	3% of municipal effluents		

Source: Culp, Wesner and Culp (1979).

difficult to distinguish between reuse and land treatment. Addition of this incidental reuse might raise the 1975 amount to about 1 bgd or about 4 percent of municipal effluents.

b. Examples of Reuse

The previous chapter provided detailed discussions on two important examples of reuse for irrigation (i.e., landscape irrigation in St. Petersburg, Florida, and an agricultural reuse project at Northglenn, Colorado). The following examples, drawn primarily from Culp/Wesner/Culp (1979) and the AWWA Research Foundation (1978) supplement these.

- Lubbock, Texas, has been the site of wastewater reuse for agricultural irrigation since 1938. Presently, 10 to 12 mgd are used for watering cotton, milo, grains, corn and pasture grasses.

- In Orange County, California, the Irvine Company uses 3.2 mgd of disinfected secondary effluent to irrigate orchards and row crops. A reduced need for fertilizer application has been noted.

- Part of the Colorado Springs, Colorado effluent is provided tertiary treatment (filtration) and disinfection and then used for landscape irrigation of college and industrial grounds, a golf course, and a cemetery.

- Bethlehem Steel has used Baltimore, Maryland wastewater since 1942. Presently, 107 mgd are used for cooling and processing in steel production. This is 15 percent of all current municipal wastewater reuse in the U.S.

- In Las Vegas, Nevada, municipal effluent is used to provide 35 percent of the needed cooling makeup water.

- At Whittier Narrows, east of Los Angeles, about 29 mgd of disinfected secondary effluent is conveyed from three wastewater treatment plants (Whittier Narrows, San Jose Creek, and Pomona) through flood control channels to percolation basins/spreading grounds where it is blended with imported water and used for groundwater recharge. The reclaimed water constitutes about 10 percent of basin recharge. The groundwater is subsequently used for municipal, industrial, and agricultural purposes.

- In Orange County, California, about 5 mgd of highly purified wastewater effluent is used via injection wells to create a fresh groundwater barrier against salt water intrusion.

- In Santee, California, east of San Diego, a project with capacity for 4 mgd of wastewater reclamation was developed to provide water input to a series of recreational lakes.

Each of the above is a classic example of municipal reuse. These and many other reuse projects have been developed in a pioneering spirit and thus their main significance may be to serve as a foundation for future reuse projects.

c. Federal Activities

Federal encouragement and sponsorship of wastewater reuse occurs primarily within EPA, the Office of Water Research and Technology, and the Bureau of Reclamation. Specific activities include:

- EPA Construction Grants Program. Provisions in the 1977 Clean Water Act which encourage innovative and alternative technologies for wastewater treatment are the most significant factors affecting reuse. Under these provisions, reuse qualifies for cost-effectiveness and funding bonuses which are significant incentives for reuse implementation. Land treatment is also encouraged creating an additional possibility of incidental reuse. The main uncertainties in the present program are the criteria and rules which will be used to determine funding eligibility. Specifically,

  - If a new wastewater treatment project is needed to meet or maintain water quality standards and if a reuse project is cost-effective under the 115 percent rule, it is clear that reuse portions of the project are eligible for the 85 percent Federal funding.

- It is not clear what rules will apply in cases where additional treatment works are not required to meet effluent requirements or water quality standards. This topic is presently being addressed by EPA's work group in Funding of Multiple Purpose Projects. Of particular concern are several cases in the west (especially in California) where secondary treatment plants were previously built to meet the 1977 deadline for wastewater treatment and reuse facilities were anticipated or are now being proposed as a subsequent phase. The main difficulty in establishing policy is the desire to avoid diverting funds from the primary mission (water pollution control) while still encouraging innovative and alternative approaches, particularly those which reuse water and nutrients and move toward the 1985 goal of the Clean Water Act.

. <u>EPA Water Quality Management Planning.</u> Although reuse is not given specific emphasis in the new WQM regulations, consideration of reuse should occur. In particular, the WQM plan must address the following areas:

- Municipal and industrial needs (§35.1521-3(d)). WQM planning must consider whether specific treatment needs should be identified and, if fulfilling specific needs becomes part of the plan, they must be recognized by the needs inventory and priority system. Furthermore, the WQM plan is required to set forth information to support subsequent facility planning, including information on municipal facilities, suggested regional approachs, and programs to support municipal water conservation. This assignment is broad enough to accomodate identification of reuse opportunities and if it is well done, reuse will be considered.

- Conservation (§35.1521-3(h)). Where appropriate, the plan is to identify water conservation needs and practices to achieve and maintain water quality standards and to ensure efficient wastewater treatment. Conservation should be interpreted broadly in this context, thus providing the opportunity to identify reuse schemes, particularly schemes which increase low streamflows or reduce pollutant discharges in ways which enhance conformance with water quality standards.

- EPA Office of Research and Development. Basic information on the impacts of reuse is being sought through EPA's Office of Research and Development. Primary emphasis is placed on potential effects on human health.

  - The Water Quality Health Effects Program includes work on health impacts of using wastewater and sludges in agricultural irrigation and application by spraying (EPA, ORD, 1979).

  - The EPA Research and Development Act of 1978 (PL 95-155) requires the agency to spend $25 million per year in the form of 65-75 percent cost-sharing grants for the purpose of assisting in the development and demonstration (including construction) of any project which will (a) demonstrate a new or improved method, approach or technology for providing a dependable safe supply of drinking water to the public; or (b) investigate and demonstrate health and conservation implications involved in the reclamation, recycling and reuse of wastewaters for drinking and the processes and methods for preparing safe and acceptable drinking water (AWWA Research Foundation, 1978). The primary thrust of these funds is toward potable reuse demonstration as exemplified by a $7 million project in Denver.

- Office of Water Research and Technology. In response to the Water Research and Development Act of 1978 (PL 95-467), OWRT conducts an extensive program of reuse research as documented by its synthesis of project abstracts (U.S. Dept. of the Interior, OWRT, 1979). Although many of these projects focus on treatment processes to facilitate reuse, there are others which address planning, management, institutional, and legal/social impediments involved.

- Bureau of Reclamation. Under its statutory authority beginning with the Reclamation Act of 1902, the Bureau conducts general investigations to plan conservation and efficient use of water and related land resources in the 17 Western states. Reclamation of wastewaters for reuse clearly falls within the scope of this mission and is considered.

d. State Activities

California has the most active and ambitious wastewater reuse program in the Nation. About 165 mgd of wastewater was reused in the state in 1977 when, as a result of the severe drought, a goal of tripling wastewater reuse by 1982 was established (Wasserman, 1978). The Office of Water Recycling was created within the State Water Resources Control Board to pursue this goal, and projects now being planned, designed or considered for funding will come close to achieving it. Such achievement would increase national reuse by about 50 percent. The state anticipates that most of these projects will be funded under EPA's Construction Grants Program, but this is highly dependent on the multiple-purpose funding policy which EPA adopts.

Another effort in California with Federal, State and local participation, is studying the three main coastal urban areas (San Francisco, Los Angeles, and San Diego) to determine the feasibility of large-scale reuse projects. These studies are oriented toward a particularly valuable type of reuse -- salvaging of freshwater now discharged to the ocean. They could ultimately lead to new reuse projects which would total about one billion gallons per day.

In other sections of the country, interest in reuse is still evolving. Water-short areas such as Texas and Arizona are implementing reuse with an intensity which approaches that of California. There are also important projects underway or pending in the water-rich regions. On Long Island in Nassau County, New York construction is progressing on a six mgd advanced waste treatment/injection well/percolation basin project to replenish groundwater supplies and prevent nitrate contamination and salt water intrusion. And in Chicago, Illinois funding is being sought to perform planning studies on wastewater injection for the purpose of renewing potable groundwater supplies.

e. Summary Status

Reuse of municipal effluents for nonpotable purposes is now in an evolutionary phase. Interest has been increased considerably by financial incentives provided through the Clean Water Act provisions for innovative and alternative technologies (such as reuse and land treatment) and by the publicity given to earlier successful projects. Many projects are in the discussion or planning stages and wastewater reuse is expected to increase significantly within the next few years.

2. Potential for Reuse

The only available nationwide assessment of recycling and reuse potential is a recent study by Culp/Wesner/Culp (1979) -- an assessment which builds directly on WRC's Second National Water Assessment. Table IX-6 summarizes their results, the following of which are particularly important:

- Even though water withdrawals are projected to decrease in the next 20 years, gross water use is expected to increase more than 140 percent due primarily to large increases in the steam electric and industrial use categories.
- WRC anticipates that these increases in steam electric and industrial use will be served primarily by intensive recycling (i.e., these combined sectors are expected to increase recycling by about 520 percent while decreasing withdrawals by about 7 percent).
- There are large amounts of water withdrawals which could substitute reuse of wastewater and, similarly, there are large amounts of wastewater which are available for reuse.
- There are some extremely important practical considerations which have limited development of reuse in the past and will continue to do so in the future; specific limitations recognized in Culp, Wesner & Culp (1979) include:
    - The relative geographic locations of dischargers and potential users, and the resultant expense of transporting water from one to the other.

Table IX-6

PRESENT AND POTENTIAL FUTURE
SIGNIFICANCE OF RECYCLING AND REUSE

	1975 (in bgd)	2000 (in bgd)	Percent change
Gross Water Use (Withdrawals & Recycling & Reuse)			
Domestic and Commercial	29	37	+28
Agricultural Irrigation	183[a]	178[a]	-3
Steam Electric	146	597	+310
Industrial	140	380	+170
Other	4	5	+25
Total	502	1197	+140
Water Use Served By Recycling			
Agricultural Irrigation	NA[a]	NA[a]	NA[a]
Steam Electric	57	517	+810
Industrial	82	348	+320
Total	139	865	+520
Water Withdrawals Which Might Use Effluents Instead			
Agricultural Irrigation	183	178	-3
Landscaping	1	1	+23
Steam Electric	89	80	-10
Industrial	58	31	-47
Total	331	290	-12
Effluents Available For Reuse			
Municipal	21	27	+29
Agricultural	14	11	-21
Steam Electric	88	70	-20
Industrial	50	13	-74
Total	173	121	-30
Actual Present and Realistic Future Direct Reuse	0.7	4.8	+590

a. Although intensive recycling of agricultural irrigation waters is thought to occur in some locations, no data are available on its magnitude; thus only withdrawals and reuse are included

Source: Culp, Wesner & Culp (1979); numbers are based on WRC Second Assessment estimates for dry-year conditions

- The relative timing of discharges and water demand, and the resultant need for storage facilities with the associated expenses.

- The availability and relative cost of alternative sources; indeed, most potential uses identified are already served by nearby sources and existing facilities.

. Even considering the practical factors identified above, there is a potential for large increases in wastewater reuse, with Culp, Wesner and Culp estimating that about a 590 percent increase is feasible by year 2000.

Recycling (i.e., in the steam electric and industrial sectors as indicated by WRC projections) is anticipated to be the main source of "new supplies" over the next 20 years. This is expected because stringent industrial wastewater treatment requirements make recycling of the resultant clean water very practical (i.e., it is an ideal supply in terms of location, quantity, timing and dependability).

Reuse potential is also of significance, however. Especially in water-short areas of the western U.S., but also in eastern areas where new industrial and steam electric facilities will be located, wastewater will increasingly be viewed as a dependable and relatively inexpensive source of new supplies. Municipal effluents will be particularly attractive: i.e.,

. They are growing in volume.

. They are of markedly improved quality due to pollution control programs.

. They will not be subject to salt buildup due to recycling like steam electric and industrial effluents will be.

. They are dependable on a day by day basis in contrast to agricultural discharges which are highly seasonal.

Thus where location and timing are compatible, where effluents are economically competitive with alternative supplies, and where institutional issues such as water rights can be worked out, municipal effluents will be directly reused on an increasing basis. This reuse may amount to 15 to 20 percent of available municipal effluents by year 2000 as compared with the present reuse of approximately 3 percent.

3. Advantages of Reuse

Although the new emphasis on reuse in the Clean Water Act Amendments of 1977 provide a strong incentive, there is more behind the present enthusiasm for reuse than simply the desire to receive larger Federal wastewater treatment grants. The most significant advantages include:

- Water Quality. To the extent that discharges are reduced in volume, the pollutants contained by those discharges are also lessened, they may be recycled, and the country comes closer to realizing its water quality goals.

- In-stream Uses. To the extent that the demand for new water supply development grows more slowly or is lessened, waters can be left in their natural setting with consequent improvements in water quality, fish and wildlife habitat and recreation, especially during dry periods.

- Groundwater Protection. When reuse reduces demand for groundwater in areas of overdraft, it prolongs the utility of the resource both by spreading the available quantity of water over an increased number of years and by decreasing the likelihood of contamination such as by salt water intrusion. When reuse results in increased groundwater recharge (e.g., land treatment, irrigation, percolation, or injection) and is done carefully to avoid contaminating the aquifer, it increases the resource available for future use, especially during dry periods.

- Water Supplies. In regions which are water-short, reuse can simply increase usable water supplies. This is especially important in areas where water demands are growing; e.g. where population growth creates the need for increases in domestic and commercial supplies. Reuse of municipal effluents can be a significant vehicle for accommodating this growth even when the effluents themselves are not used for potable supplies. For example, municipal effluent might be exchanged for an agricultural or industrial supply of potable quality (see the Northglenn example in Chapter VIII), or municipal effluent might be substituted for industrial or landscape irrigation uses which have previously used municipal supplies (see the St. Petersberg example in Chapter VIII).

- Economic Savings. Even with advantages such as those listed above, reuse must usually provide economic savings in order to be implemented and it often does. For example, where wastewater treatment beyond secondary would be required to meet stream standards, reuse using secondary effluent can provide important savings in wastewater management costs. Even higher savings are possible if primary effluent can be utilized, for example, in irrigating foder, fiber or seed crops. Wtih undeveloped water sources becoming scarce and more expensive to tap, significant expenditures to develop new water supplies may also be avoided. It is also possible that reuse will provide an especially dependable supply and that prevention of shortages may preclude associated economic losses. All of these savings can be legitimate motivations for implementing reuse.

4. Impediments to Reuse.

Cost is the main impediment to reuse but there are also several others. These disadvantages include:

- Cost. Both capital and operating expenditures for reuse tend to be high and stem primarily from two factors:

  - Transportation and storage of reclaimed effluents are usually required. Pipelines often have to move the water uphill with associated pumping costs and the route may be through urban or semi-urban areas; these factors can increase transportation costs dramatically. The seasonal demand for irrigation water has significant implications for storage costs as well. For example, in a San Francisco Bay Area reuse study which is presently underway, the range of transportation and storage costs for the preliminary alternatives is \$130 to \$340 per acre-foot (.40 to \$1.04/1000 gallons) (Harnett and Hall, 1979).

  - Treatment of reclaimed water prior to the next use is often required; treatment requirements may be as stringent as for effluent discharge and sometimes they are more stringent. The treatment costs may be about as much as the transportation and storage costs.

The feasibility of any particular reuse project is extremely sensitive to the above costs.

Competition from Alternative Source. Water supplies can often be provided at less expense than would be required for wastewater reuse. This is primarily due to five factors:

- Present supplies are usually from relatively easy sources, which were developed at pre-inflation prices. Thus, there is little economic incentive to make a major investment in reuse as a substitute for present supplies, even if that would mean protection of in-stream uses or groundwater resources.

- Where present supplies are inadequate, new supplies may be cost-competitive with reuse because large transportation, treatment or storage costs associated with reuse may be avoided. For example, a stream channel might be used as a free conveyance facility for the new water supply or, a groundwater supply usually does not require storage or treatment.

- Large subsidies are often provided both for present water supplies and those which may be developed in the future. When a reuse project is analyzed, its desirability is strongly affected by the magnitude and sources of these subsidies.

- Conservation (the reduction of water demand) is being increasingly recognized as an inexpensive way to meet "growing" water needs. It may even cost less to reduce water use per capita or per ton of product than it would to provide additional water through reuse to satisfy growing population or production needs.

- The primary markets for use of reclaimed water (e.g., agricultural irrigation, steam electric and industrial cooling) are often the users willing to pay the least amount for water. They might find it more economical to switch products or production methods or simply not to produce rather than to pay the cost of reclaimed wastewater.

As one example of the cumulative significance of the above factors, the price presently paid for agricultural irrigation water in the Sacramento San Joaquin Delta ($11/acre-foot) can be compared with the $130 to $340/acre-foot range being found for large-scale reuse projects (Harnett and Hall, 1979). From another point of view, new water supply projects are about as expensive as reuse with an estimated cost range of $110 to $295/acre-foot. This may simply emphasize the issue of whether additional water use is justified.

- Health Risks. There is still significant uncertainty regarding the health effects of some types of reuse (e.g., irrigation of food crops, contamination of groundwater sources used for drinking, body contact recreation, aerosol transport with spray irrigation). Treatment required prior to reuse in response to these uncertainties is viewed by some to be overly conservative with consequent increases in reuse cost. As an example of present treatment requirements, the following summarizes those in effect in California (Calif. Dept. of Health Services, 1978):

  - Primary treatment is required for irrigation of livestock feed, seed crops, and orchards.

  - Secondary treatment and disinfection are required for irrigation of food crops, milk-animal pastures, and landscaping and for groundwater recharge through percolation ponds.

  - Advanced waste treatment and disinfection are required for park and playground irrigation, body contact recreation, and groundwater recharge by injection.

  The above requirements are formal standards for irrigation and recreation reuse, and although the treatment requirements for groundwater recharge are determined on a case-by-case basis, they usually conform with the above summary. The advanced waste treatment for groundwater is oriented primarily to solids removal to maintain the aquifer's transmissibility. Some of these requirements might be reduced if further research and demonstration makes a strong case that health risks would be minimal with less conservative standards.

- Energy Consumption. The potential need for pumping reclaimed water to the use site may make a proposed reuse project relatively energy-consumptive. The treatment required and construction of facilities for transportation and treatment also consume significant amounts of energy. Clearly, energy implications must be evaluated primarily on a case-by-case basis. Results will depend on the energy required to develop an alternative source.

- In-stream Uses. Reuse may be beneficial to in-stream uses by lessening the extent to which a source is developed and thus leaving more water in source streams. However, there is presently no assurance that such beneficial effects will continue. After a short period some other user might divert the water for his use, and the in-stream uses would then be just as bad off as before, perhapd even worse off. In-stream uses may also be adversely affected by removal of a prior wastewater discharge. Flows with the discharge may be adequate to support a fishery or to maintain downstream wetlands. However, without the discharge, these features may be more vulnerable during dry periods.

- Water Rights. Off-stream users located downstream from a wastewater discharge may be harmed if that discharge is eliminated or reduced by reuse. In this case, however, the downstream user may have legal recourse. Depending on the specific circumstances, he may have as strong a claim to the discharged water as he would have to a natural streamflow that he had developed and for which he had filed water rights.

- Psychological. Public perceptions and acceptance of wastewater reuse are particularly intangible and volatile. These aspects present a two fold problem to contend with in promoting reuse: (1) a real reluctance to use wastewater and (2) the strong possibility of either over- or under-estimating the reluctance or misinterpreting it. Clearly, the importance of these psychological aspects must not be neglected and an extensive educational effort may be necessary to overcome them.

5. Findings

The foregoing analysis of reuse of municipal wastewater effluent for nonpotable purposes leads to the following findings:

- Reuse is being given significant attention by the Federal government, especially in EPA's Construction Grants Program which gives financial support to reuse projects through the innovative and alternative provisions of the Clean Water Act. These provisions, their legislative history, and the implementing regulations make clear the national intention to achieve greater reclamation and reuse of water, productive recycling of wastewater constituents, and recovery of energy and to otherwise eliminate the discharge of pollutants.

- Reuse of municipal effluents has several advantages:

    - It can be a source of relatively high quality water, and is particularly attractive when compared to the expected salt buildup in intensively recycled steam electric and industrial effluents.

    - It is increasing in volume and quality in contrast to most other potential sources of supply.

    - It is a dependable supply and is evenly distributed over time and located near urban areas. These can be favorable characteristics for steam electric and industrial supplies and, to a lesser extent, for landscape irrigation.

    - Even when disregarding reuse as a source for potable supplies, it can provide a vehicle (through substitution or exchange) for obtaining potable water from other uses to supply the needs of growing municipalities.

    - Reuse has particular appeal from a resource management viewpoint in water-short and coastal areas where it may significantly supplement supplies and postpone the loss of relatively high quality freshwater to saline environments.

  - It can also provide important environmental benefits in terms of improved surface water quality, protection of groundwaters, and enhancement of in-stream uses.

- There are also significant impediments to widespread implementation of reuse:

  - It tends to be costly.

  - Alternative water supplies or alternatives to additional water supply are often less costly.

  - There are uncertainties about potential health effects and the degrees of treatment needed to protect against them.

  - In-stream uses and water quality may benefit only for a short time or may be adversely affected.

  - Downstream water rights may have claim on discharges.

  - Psychological acceptance of reuse is critical.

- Much of the presently available information on reuse is on the use and effectiveness of various treatment techniques prior to reuse. In contrast, information on the realistic potential of reuse, its general economic feasibility, and the actual risks of health effects has only recently been given emphasis.

- Since the beneficial impacts of reuse on in-stream flows and water quality may be lost after a short period of time by appropriation of flows for off-stream use, there is a danger that Clean Water Act funds will not have made their intended contribution toward enhanced water quality.

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Chapter X

GROUNDWATER MANAGEMENT AND INTEGRATION WITH SURFACE WATERS

A. Overview

1. Relationship to Parts 1 and 3

Groundwater is a source of drinking water for approximately 103 million people in the United States, including an estimated 95 percent of the rural population. Based on the finding in Part 1 that groundwater has not been addressed adequately, this chapter reviews quantity and quality problems and selected case histories of management approaches to these problems. Part 3 then identifies actionable items for better protecting and managing groundwater.

2. Types of Problems

The various quantity and quality problems which affect groundwater have been grouped into three sections - overdraft, contamination from waste disposal, and surface water interactions. This chapter discusses both quantity and quality aspects in each of these sections. The overdraft section (i.e., withdrawal of groundwater at rates greater than replenishment) discusses problems due to inadequate supplies, land subsidence, salt water intrusion, well interference, and induced contamination. The contamination potential from surface impoundments, landfills and dumps, injection wells, and nonpoint sources are discussed in the waste disposal section. Surface water interactions described include natural and artificial recharge, excessive pumping of groundwater, and inflow of contaminated surface water.

As the variety of problems listed above indicates, there are many direct and indirect pathways to groundwater. The flow in most aquifers is slow, on the order of a few feet per day or less. Thus, if pollutants reach an aquifer, a long time is required to flush the aquifer. The contaminated groundwater may not be discovered until the plume reaches a well or surface water. Clean-up operations are costly, difficult, and in some cases impossible. Because of these factors, groundwater protection is essential. Another factor which stresses the need for protection of aquifers used for drinking water sources is that many people use groundwater with little or no treatment.

3. Relationship to Other Studies

Several studies and task forces are currently investigating groundwater in response to the President's Water Policy, the Safe Drinking Water Act and the Clean Water Act. Input from these studies has been obtained where possible. The President's Water Policy is briefly discussed and three studies are summarized below which involve developing policy options or actions that the Federal government can take to better protect groundwater quality and to encourage integrated management of surface and groundwater. Although numerous reports on groundwater problems were reviewed for this study, the purpose in highlighting the three aforementioned studies is to include their recommendations so that present efforts to improve groundwater management and protection are properly identified.

a. President's Water Policy

The President's Water Policy, presented to Congress on June 6, 1978, includes as primary concerns: Federal water programs, conservation of water, environmental protection, and improved Federal/state cooperation in water planning and policy development. The implementing directive on Environmental Quality and Water Management of July 12, 1978 includes several references to groundwater as an integral part of the Nation's water resource.

The Secretary of the Interior was delegated the responsibility for implementing the Water Policy. Nineteen interagency task forces were set up to develop plans and recommendations. One of these task forces addressed groundwater supply issues with subtask groups to look at Federal/ state cooperation, water resource projects, and budgets.

The work and recommendations of the Groundwater Task Force is reviewed in more detail in the next section. The Groundwater Task Force in conjunction with the Instream Flows Task Force prepared a summary by agency of Federal technical assistance and information available to states on groundwater and in-stream flows (U.S. EPA, 1979a). Another joint project was the compilation of general information on FY 1980 Federal agency programs and budgets relating to groundwater and in-stream flows.

b. Groundwater Interagency Task Force

This task force included representatives from the Department of Interior, EPA, Army Corps of Engineers, Department of Agriculture, Tennessee Valley Authority, and three representatives from outside of the Federal government.

Their objective was to develop recommendations for implementing the Water Policy as it relates to groundwater. The main points in the Environmental Quality and Management directive were: (1) to ensure that the environmental impact and potential use of groundwater are considered in the planning process for Federal water resource projects, (2) to identify groundwater problems in the states and to ensure that Federal actions do not contribute to these problems, and (3) to coordinate Federal/state actions to avoid or to alleviate groundwater problems.

The Groundwater Task Force concludes that impacts affecting supply and quality may result from many types of Federal actions and programs, and that guidelines for consideration of groundwater in the planning process should be applied to all Federal agencies, not just to major water resource projects. The primary concerns addressed by the task force were groundwater depletion, quality degradation, planning and management deficiencies, legal problems, and relationship of groundwater to in-stream flows. Mechanisms that the Federal government can employ to alleviate these problems by direct action or by assistance to state and local government were also reviewed.

The final recommendations of the task force (EPA, 1978b and c; 1979b) have not been completed. The preliminary recommendations for Federal actions include (1) to modify the Water Resources Council "Principles and Standards for Planning Water and Related Land Resources" and associated guidelines and procedures manuals to include groundwater in the planning process, (2) to evaluate groundwater as a possible substitute for Federal surface water projects, and (3) to identify impacts the proposed projects might have on the quantity or quality of groundwater. A groundwater assessment report would be prepared for each project. Other Federal actions suggested were effective management of groundwater by agencies with control of Federal lands, further groundwater research and data collection efforts, and establishment of an Interagency Coordinating Committee. Preliminary suggestions for complementary state actions include development of legal and administrative measures to protect groundwater, integrated management of surface and groundwater, and encouragement of conservation.

c. Water Allocation/Water Quality Coordination Study

A study by the Water Planning Division of EPA was made to examine the relationships between the Clean Water Act's pollution control programs and water allocation programs of the states and Federal government. The study is required by Section 102(d) of the Act. In addition to analyzing these relationships, the study is to include recommendations for coordination of pollution control efforts and management of the water resource. A draft report (U.S. EPA, 1979d) was prepared in January, 1979 but recommendations are not yet available.

The study reviewed the Clean Water Act programs, the intent of Section 101(g), Federal and state laws governing water allocation, and laws applicable to Federal/state conflicts and interstate conflicts. The draft report summarizes potential quality/quantity conflicts, existing Federal authority over groundwater, and effects of state laws affecting allocation.

d. Groundwater Policy Committee of EPA

A task force has been set up within EPA to develop actions to improve groundwater protection. A contractor will assist the Groundwater Policy Committee to review existing EPA responsibilities and programs and to make recommendations on ways to better protect groundwater quality. The contractor will review legislation, existing EPA and state programs, groundwater problems, and several recent case histories. The case histories will be used to identify problems and develop suggested plans for improvements. The study may identify ways to coordinate state and EPA actions to protect groundwater quality and areas where problems with hazardous materials exist that may not be adequately covered.

B. Extent and Severity of Problems

Three principal groundwater problems are discussed in this section: overdrafting, contamination by waste disposal operations, and surface water interactions. The purpose is to outline the extent of these and related problems on a national and regional basis and to identify the impacts on aquifers used as drinking water sources.

1. Overdrafting

Extensive mining of groundwater depletes the supply faster than the water can be replenished by precipitation or recharge, and uncontrolled pumping may lead to water supply shortages, land subsidence, or quality problems. Groundwater mining provides approximately 20 of the 80 bgd of groundwater withdrawn (WRC, 1978a). (Regions where overdrafting occurs are identified in Part 1, Chapter III.) In some areas, such as the Texas High Plains, mining of the Ogallala aquifer supplies nearly 50 percent of the water consumed. Of eleven hydrologic basins in California eight are withdrawing groundwater at rates above the safe yield of the basin. The groundwater mining accounts for 30 percent of the total groundwater withdrawn or 2.2 million acre feet/year (2 bgd) (California Department of Water Resources, 1974).

a. Disruption of Water Supplies

Extensive pumping of an aquifer may deplete the supply by lowering the water level below economically feasible pumping lifts, causing shallow wells to go dry, and increasing well interference. In areas such as those mentioned above, it is likely that much irrigated agriculture now dependent on groundwater mining will eventually have to abandon or greatly reduce irrigation. In the meantime most rural domestic and community wells in these areas will have to be repeatedly augmented (at major expense) as water levels fall simply to maintain present withdrawals. In some areas, water levels have been falling rapidly enough to warrant serious concern:

- In the south-central Arizona area, groundwater levels are presently declining on an average of 8 to 10 feet per year (WRC, 1978b).

- In the high plains area of Texas, New Mexico, Oklahoma, Kansas, Nebraska and Colorado, the Ogallala aquifer is the predominant source of water supply and is being severely overdrafted. In the 15 county area of Texas served by High Plains Underground Water Conservation District No. 1 the average rate of water-level decline averaged over the total area and a ten-year period has been about 2 feet per year. (Smith, 1979). In the Texas and New Mexico areas which are irrigated, the underlying groundwater table has been declining at approximately 3.5 feet per year on the average (WRC, 1978c). In more limited (but still extensive) areas, the average rate of decline can be as high as 10 feet per year (Smith, 1979). Depletion of the Ogalla aquifer is now the subject of a major Federal study through the Department of Commerce.

- In the San Joaquin Valley of California groundwater overdraft continues at about 2.0 million acre-feet per year (Peters, 1979). Although overdraft and groundwater level decline have been significantly lessened in some areas by Federal and state water projects (California DWR, 1975 & 1976) additional land has been brought into production with resultant increases in overdraft in other areas (Peters, 1979). Rates of water table decline still approach 8 feet per year (California DWR, 1974) in extensive areas, especially in Kern and Fresno Counties.

b. Land Subsidence

The loss of water, particularly from fine grained aquifers, can cause compaction of the aquifer material resulting in land subsidence. This is a major problem in Arizona, California, Louisiana, Nevada, and Texas. In the San Joaquin Valley, California piezometric heads have declined by 200 to 600 feet resulting in a drop of land-surface elevation of at least one foot over 4,200 square miles. The maximum land subsidence in the western part of the area was 28 feet (Comptroller General, 1977). Land subsidence in the Houston-Galveston, Texas area of a maximum of eight feet has caused flooding and structural damage to roads and buildings.

c. Saltwater Intrusion

Water quality degradation may occur from overdrafting by causing the flow of saline water into aquifers. In coastal areas the saline water comes from estuaries, bays, or oceans. Inland areas may also have saltwater intrusion from saline aquifers which are below the freshwater aquifers. Table X-1 summarizes the types of saltwater intrusion problems found in 43 states.

Table X-1

TYPES OF SALTWATER INTRUSION PROBLEMS BY STATES

Number of States* Affected	Type of Salt Water Intrusion
27	Lateral intrusion caused by excessive pumping
11	Vertical intrusion caused by excessive pumping
8	Improper disposal of oil field brines
6	Intrusion caused by faulty well casings
5	Surface Infiltration
5	Layers of salt water in thick limestone formations
2	Vertical intrusion caused by dredging
2	Irrigation return flow

*States may have more than one kind of problem.

Source: Newport (1977)

Although the most severe problems were in coastal areas, 22 inland states had saltwater intrusion problems. The potential for inland problems is apparent considering that one-third of the U.S. has aquifers less than 1,000 feet deep with TDS concentrations over 1,000 mg/l and another third has deep aquifers over 1,000 mg/l. Figure 10.1 shows the regions where groundwater mining is occurring within the saline aquifer zones including Kansas, Oklahoma, Nebraska, New Mexico, and parts of Arizona, California, Louisiana and Michigan. Groundwater mining within the coastal zones is occurring in parts of Florida, Georgia, South Carolina, and California in addition to the inland areas of the above states.

There are various control measures which can be used to help remedy saltwater intrusion problems. Freshwater barriers have been used in the Los Angeles County region in addition to management of the groundwater basin. Artificial recharge has been used in Santa Clara County, California and may be used in Cocoa Beach, Florida. Reduced pumping is the most common approach and has been used in six coastal states and two inland states. In some areas wells had to be relocated, including sites in eight coastal regions and two inland areas.

Saline water may also enter a freshwater aquifer by movement through damaged casings or abandoned wells or from improper disposal of oil field brines. Proper plugging of an abandoned oil well near Terre Haute, Indiana and subsequent pumping of the supply wells 2,000 feet away, reduced the chloride concentration from 550 ppm in 1955 to between 62 and 14 ppm in October, 1958 (Newport, 1977). This kind of solution would be applicable only to localized saline water problems.

Brine disposal may be injection into the oil producing formation or other saline aquifers; by use in enhanced recovery operations; by discharge to surface water, sealed or unlined pits; or by other methods. The types of disposal methods used in the major oil producing states and numbers of saltwater disposal wells and impoundments are shown in Figure 10.2. The total number of saltwater disposal wells and oil and gas related impoundments are estimated to be 40,000 (ADL, 1979) and 71,632, respectively (Geraghty and Miller, 1978). As shown in

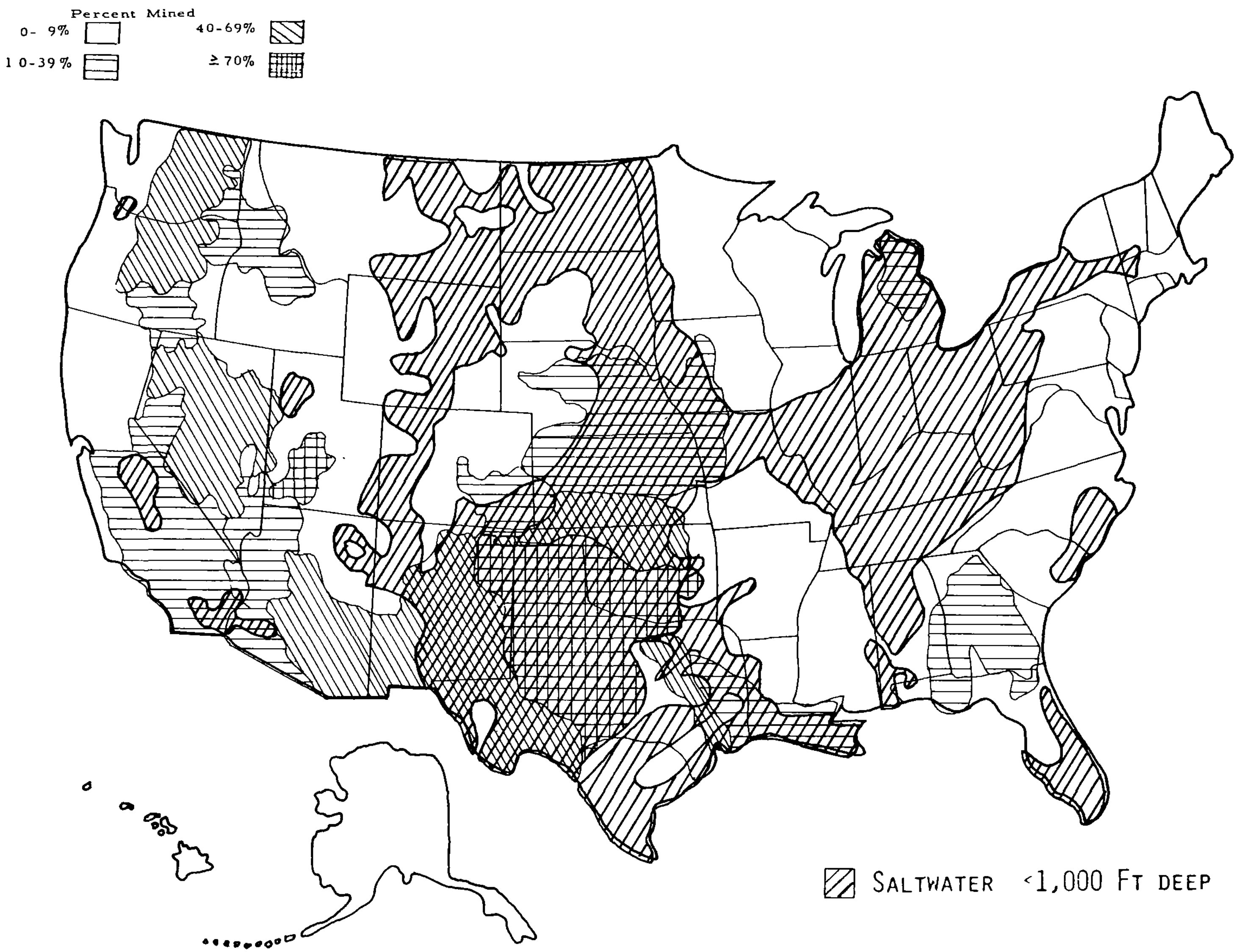


Figure 10.1 MAP SHOWING AREAS WITH GROUNDWATER MINING AND POTENTIAL FOR SALTWATER INTRUSION

Sources: Groundwater Mining Map: Water Resources Council (1978); Saltwater Aquifer Map based on EPA (1976a).

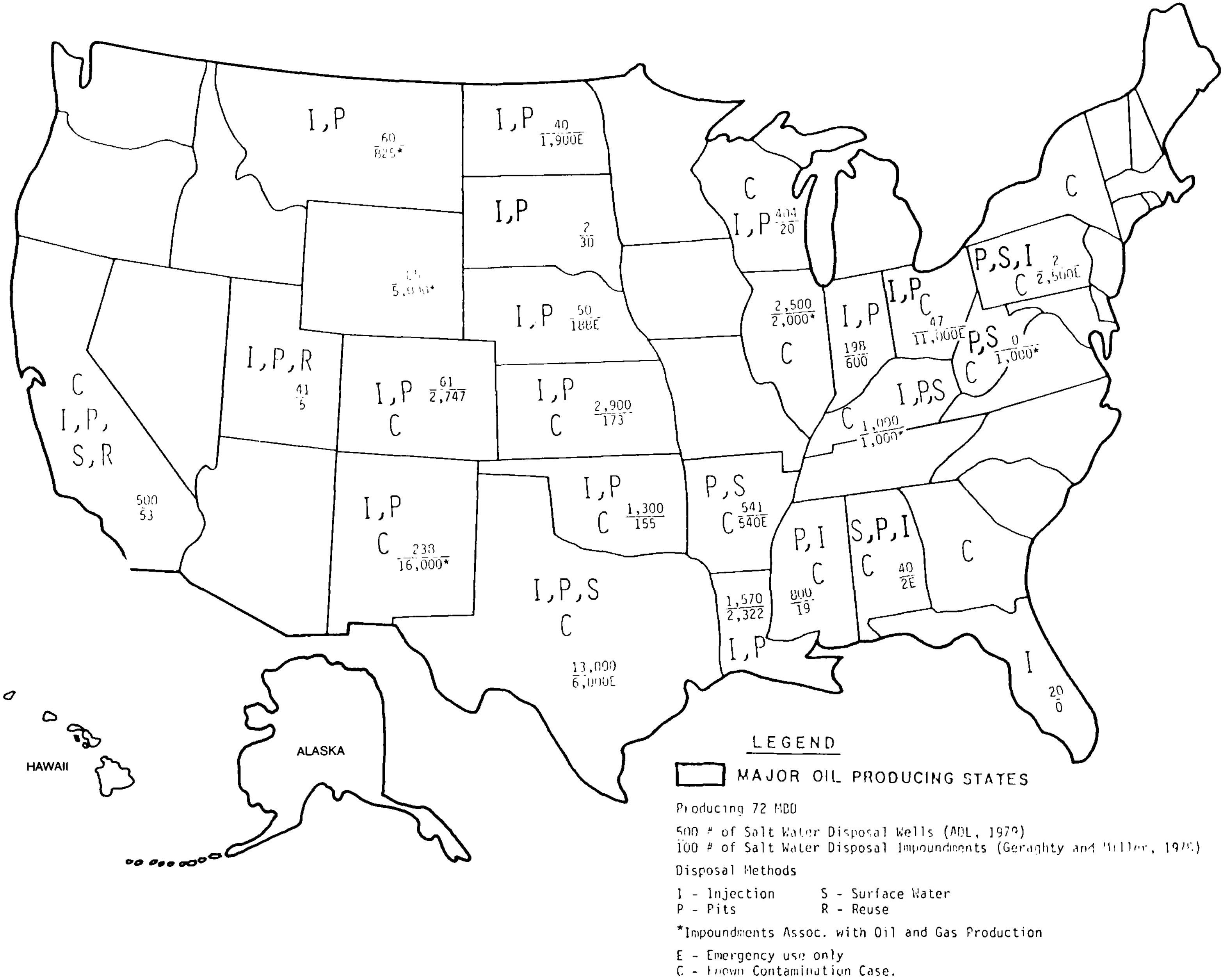


Figure 10.2 BRINE DISPOSAL METHODS USED IN THE MAJOR OIL PRODUCING STATES

Figure 10.2, the highest number of brine disposal wells is in Texas and the highest number of saltwater disposal impoundments is in Louisiana.

Contamination of water supplies has occurred from disposal of oil field brines in the states identified in Figure 10.2. Some contamination resulted from earlier practices such as large unlined seepage pits. The major constitutents in oil field brines and the range of concentrations are listed in Table X-2.

Table X-2

MAJOR CONSTITUENTS IN OIL FIELD BRINES

Parameter	Amount, mg/l*
Chloride	30 - 403,200
Sulfate	0 - 2,300
Carbonate	0 1,200
Bicarbonate	60 - 1,850
Sodium	20 - 66,300
Calcium	5 - 206,300
Magnesium	1 - 7,300
TDS	1,000 - 642,800

*Based on samples from 12 areas

Source: EPA (1977c)

Three constituents listed in Table X-2 are included in the secondary drinking water standards--chloride, sulfate, and TDS. TDS concentrations of the entire range exceed the standard of 500 mg/l. The chloride standard of 250 mg/l was exceeded in ten of the 12 areas. The sulfate standard of 250 mg/l was exceeded in four of the 12 areas. In addition to these factors the high sodium concentrations would be harmful to people with heart trouble. The contamination potential from saltwater disposal wells is considered highest of all oil and gas related wells (ADL, 1979).

2. Contamination by Waste Disposal

Waste disposal either on land or directly into aquifers can result in degradation of groundwater quality and even loss of the supply as a drinking water source. This section discusses the national and regional extent of several types of disposal including impoundments, landfills and dumps, underground injection and nonpoint waste sources. The impact of the waste on drinking water supplies depends on the volume, the chemical and physical properties of the waste, the disposal method, the characteristics of the soil and geologic formations at the disposal site, the type of aquifer, the depth to groundwater, and the flow regime. A qualitative assessment of the impacts of these disposal operations on aquifers used as drinking water sources is made based on number and concentrations of sites, volume and toxicity of wastes, and known contamination cases.

a. Impoundments

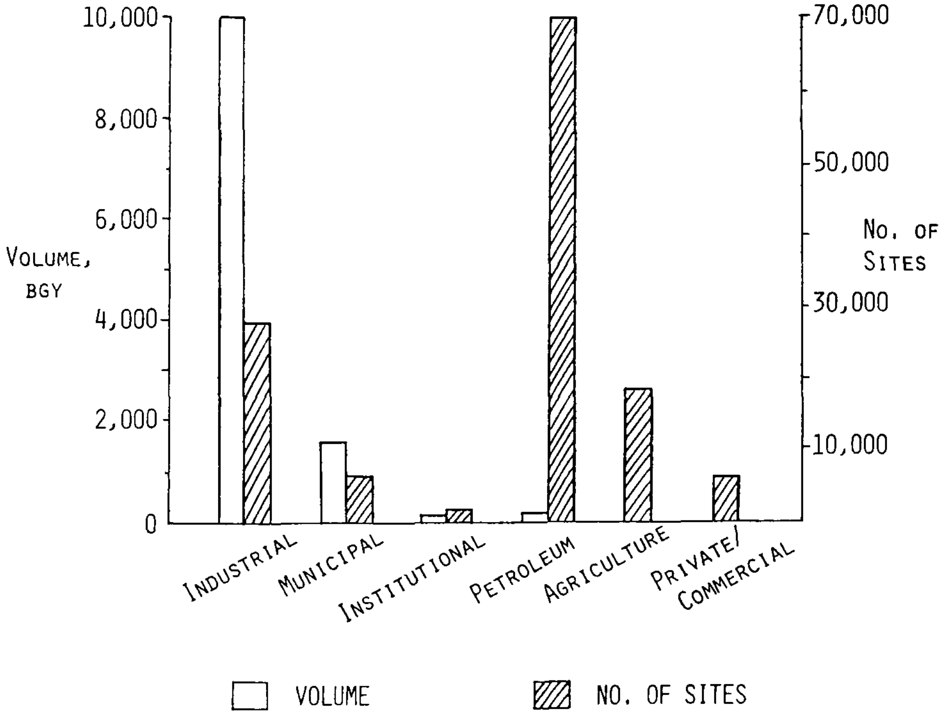
Surface impoundments under the Safe Drinking Water Act include any natural or man-made pits, ponds, lagoons, or depression with its width greater than its depth and used primarily for disposal of liquid wastes (U.S. EPA, 1978a). Impoundments may be used for disposal of wastes by evaporation, seepage, or containment; for treatment of wastes by aeration, oxidation, stabilization, or settling; or for temporary, permanent, or emergency storage of wastes.

The actual number of impoundments is not known. A detailed surface impoundment assessment (SIA) is being conducted by the states with grants under the Act but will not be completed until June, 1980. The SIA will provide data on number of impoundments, type and volume of waste, location, and user. The data are to be entered into a data base with a preliminary evaluation of potential for contaminating water supplies. The evaluation system, based on a modified Le Grand System, rates the unsaturated zone, groundwater availability and quality, and waste hazard potential, and from these factors estimates the overall groundwater contamination potential and the endangerment to water supplies. In lieu of the SIA data base the preliminary survey of surface impoundments (Geraghty & Miller, 1978) is used in this report.

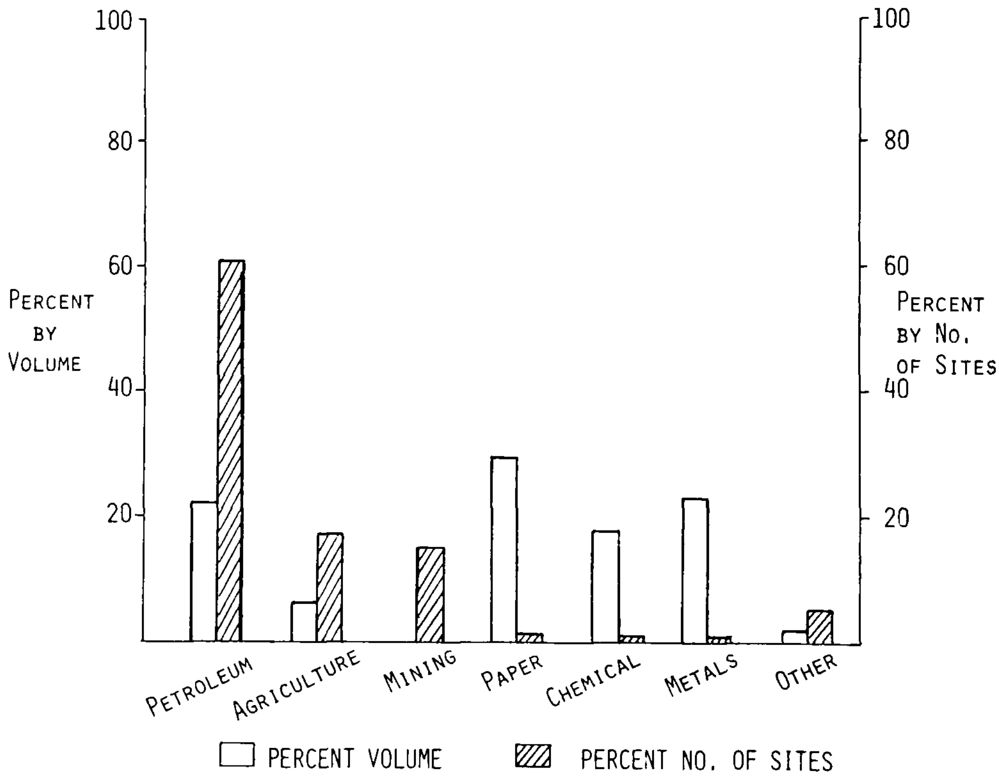
The total number of impoundment sites is estimated as 132,712. If the average number of impoundments per site is two to three, the number of impoundments would be between 265,400 and 398,100. The estimated volume of waste disposal through industrial, municipal, institutional, and oil and gas impoundments is 11,643 billion gallons per year (bgy). Volume estimates for farm and private/commercial impoundments are not available. The number of impoundment sites and waste volumes by user and types of industry are shown in Figures 10.3a and 10.3b, respectively. Industries dispose of the largest volumes of waste in impoundments although petroleum extraction operations have the largest number of sites. The breakdown by type of industry shows that while the paper, chemical, and metal industries have only a small number of sites (about 2,064) the volumes of waste are high (about 7,000 bgy). This concentration of waste at relatively few sites increases the contamination potential for drinking water supplies.

The relative number of impoundments by state is shown in Figure 10.4. The numbers of manufacturing and mining establishments by state are also shown to give an indication of the use of the impoundments. The large number of impoundment sites and waste volumes in the Gulf Coast and Rocky Mountain states are associated with oil and gas extraction with the next highest volumes associated with the chemical and paper industries. Ohio has a large number of impoundment sites associated with oil and gas extraction but the largest volumes are disposed of by the metal and chemical industries. Of these the metal and coal mining and processing industries use the largest number of impoundment sites and the largest volumes. The Pacific Northwest and Southeast regions dispose of high volumes of paper and chemical industry waste. The Western Great Lakes region discharges high volumes of waste from the metal mining and processing industries along with agricultural and paper waste.

Contamination of aquifers from surface impoundments has been described in several reports (Geraghty and Miller, 1978; Miller, _et al_.,



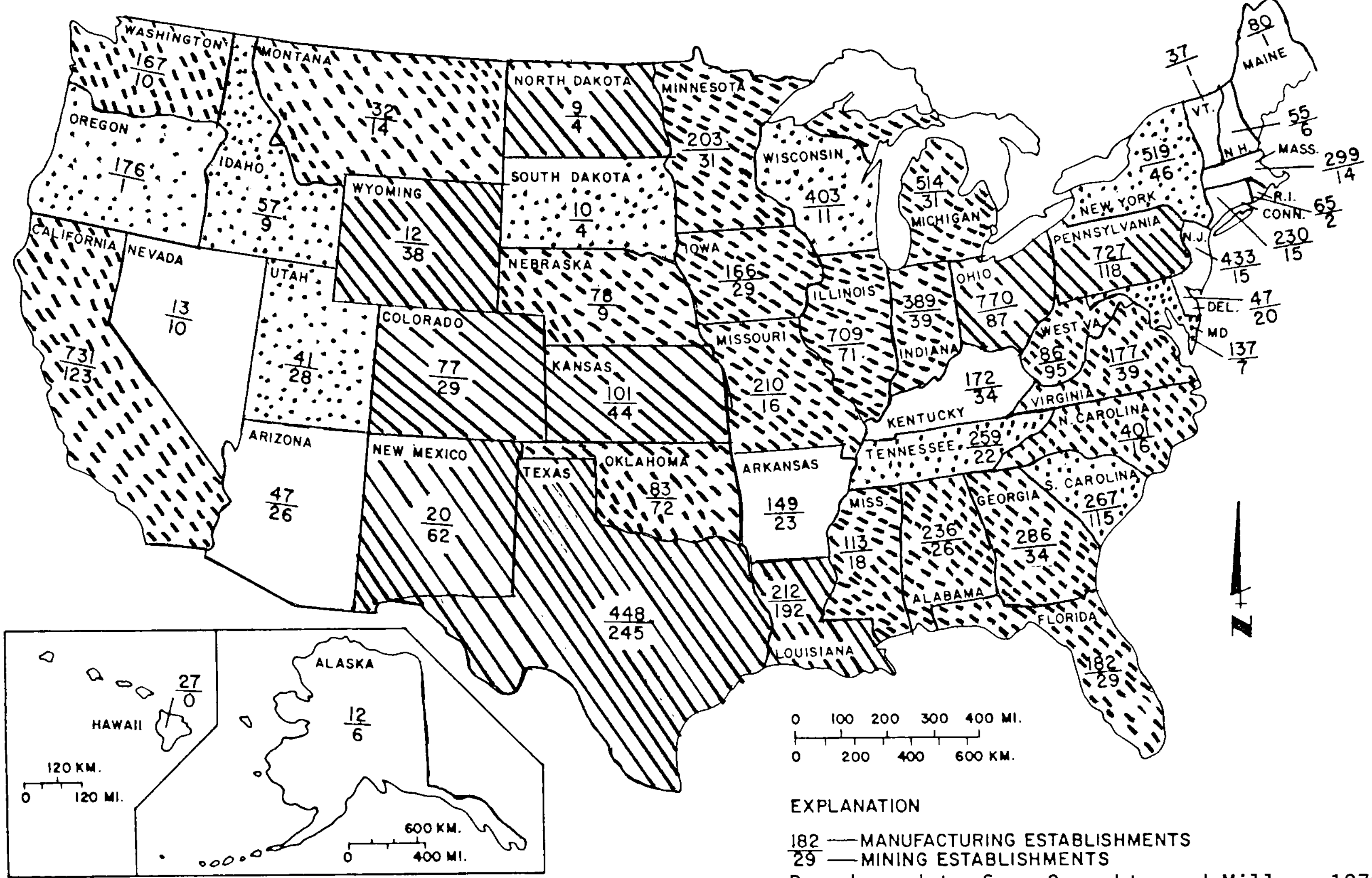
a. Volume and Number of Impoundment Sites by User



b. Breakdown by Type of Industry

Figure 10.3 USE OF IMPOUNDMENTS

Source: Geraghty and Miller (1978)



Based on data from Geraghty and Miller, 1978.

TOTAL IMPOUNDMENTS

- <500
- 501-1,000
- 1,000-5,000
- >5,001

Figure 10.4 LOCATION OF IMPOUNDMENT SITES BY STATE

1974; EPA, 1977b and c). Table X-3 summarizes 85 cases obtained from 29 states for the preliminary surface impoundment survey. The greatest number of cases occurred in the chemical products industries which was also responsible for the highest number of water supply wells contaminated. The second largest number of cases occurred in the primary metals industry. The chemical and metal products industries also accounted for the most contamination cases out of 57 cases in the Northeast region (Miller, et al., 1974). The contaminants which may be present in industrial waste will be discussed at the end of this section on waste disposal methods.

Table X-3

EXTENT OF CONTAMINATION - IMPOUNDMENTS

Industry	Contam. Cases #	Contam. Cases %	% of Cases Where Site Aband.*	% of Cases Wells Lost**
Mining	3	3	-	-
Paper Products	6	7	11	7
Chemical Products	26	31	22	43
Primary Metals	15	18	22	14
Oil & Gas	12	14	45	22
POTW	6	7	-	-
Agric. Processing	7	8	-	-
Misc. Waste Disposal	10	12	-	14
TOTAL	85	100	100	100

* Number of Cases = 22

** Number of Cases = 12 but several wells could be lost per case. In addition to lost wells groundwater degradation occurred in 69 other cases

Source: Geraghty and Miller (1978)

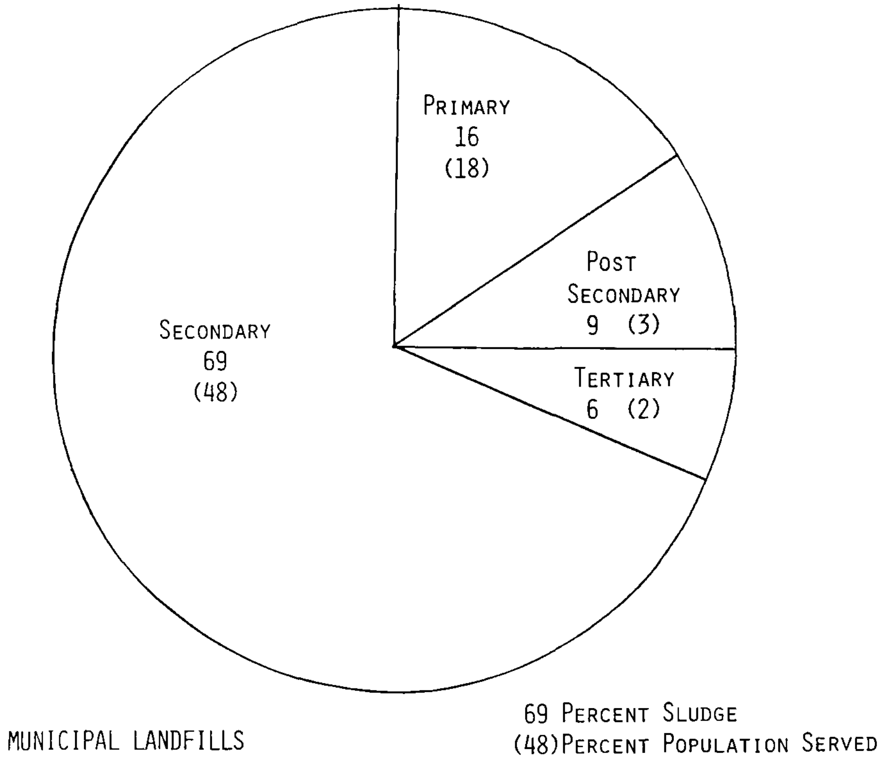
Another study (EPA, 1977b) sampled 50 industrial waste disposal sites in the eastern U.S. for organics and heavy metals and found metal concentrations above background in 43 sites and organic contaminants in 40 sites. The constituents most often found above background concentrations from highest to lowest were selenium, barium, cyanide, copper and nickel. The least frequently found constituents were lead, mercury, and molybdenum.

b. Landfills and Dumps

Solid waste may be disposed of in sanitary landfills, dumps, or the ocean. As mentioned in Part 1, Chapter IV, one of the goals of the Resource Conservation and Recovery Act is to close all open dumps within five years after the solid waste disposal site inventory is completed or to upgrade the existing facilities to sanitary landfills. The phasing out of ocean disposal of sludges by December, 1981 may increase the volumes of sludge disposed of on land.

The volumes of sludge disposed of in municipal and industrial landfills by percent are shown in Figure 10.5. The total sludge from domestic wastes disposed of in municipal landfills was about 135 million tons per year (mty) (EPA, 1977c). The largest contribution of sludge is from secondary wastewater treatment plants since the highest population is served. In addition some industrial waste is presently disposed of to municipal landfills. The number of municipal landfills was estimated as 18,500 (EPA, 1977c). These are distributed throughout the country although more sites are located in the heavily populated regions including the East, Gulf, and West Coasts and the Great Lakes region. The major constituents in digested domestic sludge are listed in Table X-4 with the expected concentration ranges. The concentrations of some metals can be quite high such as 50,000 ppm zinc and 30,000 ppm chromium partly due to the inclusion of some industrial waste.

The total volume of industrial sludge including pollution control residuals was estimated as approximately 260 mty based on data for 1971 to 1975. The breakdown by type of industry on a percentage basis is included in Figure 10.5. The chemical products industries have



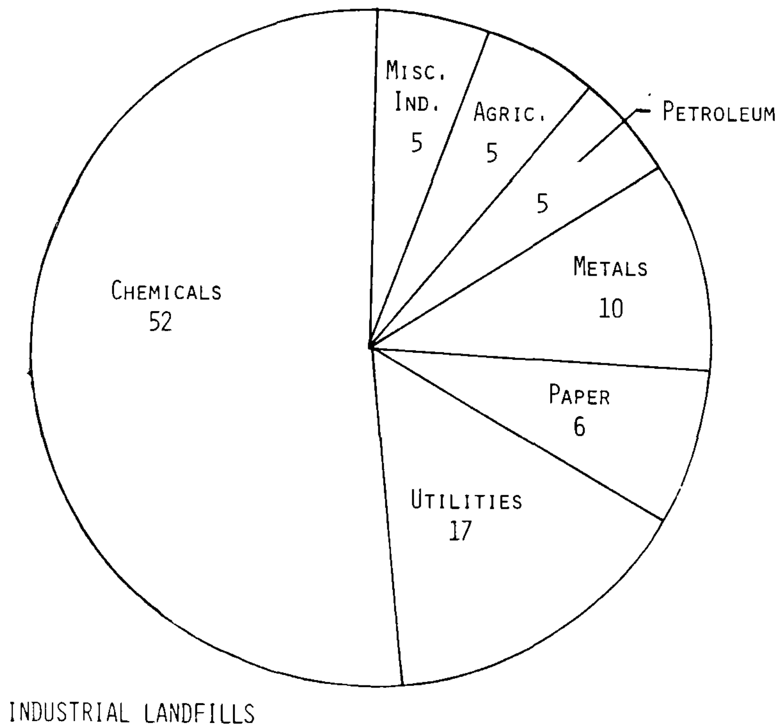


Figure 10.5 SLUDGE VOLUME DISPOSED OF IN MUNICIPAL AND INDUSTRIAL LANDFILLS

Source: EPA (1977c)

Table X-4

CHEMICAL COMPOSITION OF DIGESTED DOMESTIC SLUDGE

CONSTITUENT	RANGE, PERCENT OF TOTAL SOLIDS	
Grease and Fats	5-20	
Nitrogen	1-6	
Phosphorus	1-4	
Potash	0-3	
Iron	3-8	
Silica	10-20	
Zinc	500-50,000	PPM
Copper	250-17,000	
Nickel	25-8,000	
Cadmium	5-2,000	
Boron	15-1,000	
Lead	100-10,000	
Mercury	<1-100	
Chromium	50-30,000	
Alkalinity	2,500-3,500	
Organic Acids (as HAc)	100-600	
pH	6.5-7.5	

Source: EPA (1977c)

the largest volumes of sludge and coal-fired utilities have the second largest volumes. Projections from these data to 1977 show a total sludge volume for all industries of 396 mty of which 6.8 mty is hazardous waste.

Contamination cases have occurred from both municipal and industrial landfills as shown by a summary of cases in the northeast (Table X-5). Water supply wells were affected in 25 out of the total of 60 cases (41 percent) and the wells abandoned in 9 cases (15 percent). The type of contamination differed between municipal and industrial landfills in that toxic substances were the primary pollutants in 78 percent of the industrial landfills and only 12 percent of the municipal landfills. Under adverse geologic and hydrologic conditions wide-spread contamination of aquifers can result such as occurred at a landfill located in a gravel pit which caused the loss of 33 residential wells, 8 public supply wells, and 3 industrial wells (EPA, 1977c). Costs to provide alternative water supplies and take the corrective action of pumping out the contaminated water in this case were more than $2 million.

c. Underground Injection Wells

Protection of groundwater used for drinking water sources is included in the Safe Drinking Water Act. The regulations covering the technical criteria and standards for the Underground Injection Control (UIC) Program were reproposed and published in the Federal Register on April 20, 1979 (40 CFR Part 146). The regulations covering the permit procedures will be included in the new consolidated regulations for NPDES permits, Resource Conservation and Recovery Act, and the UIC program (40 CFR Parts 122-124) to be published soon. The injection practices to be included in the UIC program are divided into five classes as follows:

- "Class I includes industrial and municipal disposal wells and nuclear storage and disposal wells that inject below all underground sources of drinking water in the area.

Table X-5

EXTENT OF CONTAMINATION BY LANDFILLS

	Type of Landfill		
	Municipal	Industrial	Combined
Contamination Cases			
Number of Cases	42	18	60
Percent of Cases	70	30	100
Landfills Abandoned			
Number of Cases	6	8	14
Percent of Cases+	43	57	23
Water Supply Wells Affected			
Number of Cases	16	9	25
Percent of Cases+	64	36	42
Water Supply Wells Abandoned			
Number of Cases	4	5	9
Percent of Cases+	44	56	15

+Percentages based on number of cases in the category except for Combined Landfills which is based on total number of cases.

Source: Miller, *et al*., 1974

- Class II includes all injection wells associated with oil and gas storage and production.

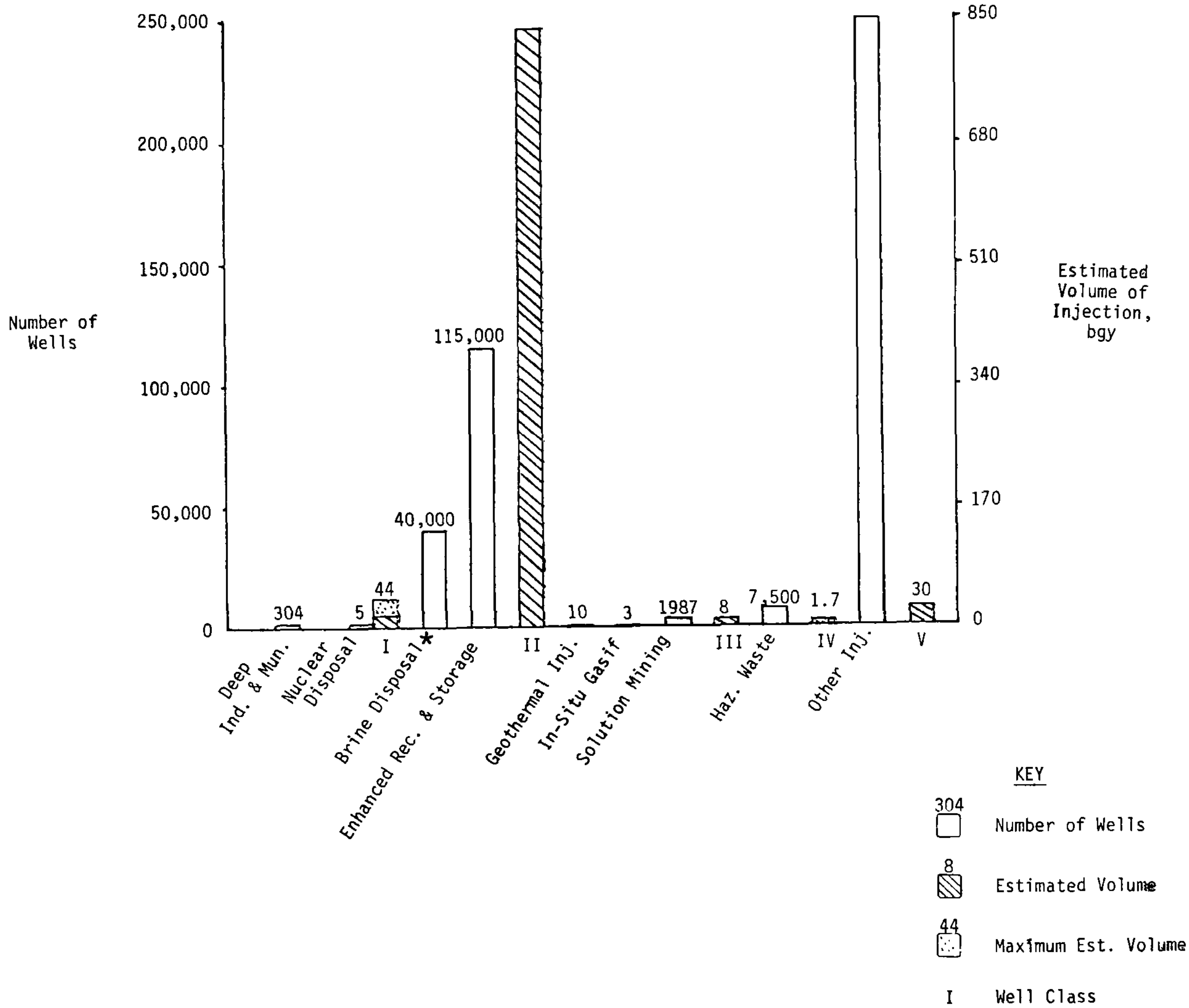
- Class III includes all special process injection wells, for example, those involved in the solution mining of minerals, in situ gasification of oil shale, coal, etc., and the recovery of geothermal energy.

- Class IV includes wells used by generators of hazardous wastes or hazardous waste management facilities to inject into or above underground sources of drinking water.

- Class V includes all other injection wells. Generally, wells covered by this Subpart inject non-hazardous fluids into strata that contain underground sources of drinking water. It includes but is not limited to the following types of injection wells; waste disposal wells, such as dry wells, non-residential septic system wells, and sand backfill wells; and recharge wells, such as drainage wells, cooling water return flow wells, air conditioning return flow wells, salt water barrier wells and subsidence control wells (not associated with oil and gas production)." (40 CFR Part 146, April 20, 1979).

The proposed definition of underground drinking water sources is aquifers with less than 10,000 mg/l TDS or aquifers presently used as drinking water sources. States may exclude all or portions of aquifers which cannot serve as drinking water sources due to severe contamination, use for producing oil, minerals, or geothermal energy, or depth or location if use of water for drinking is technologically or economically impractical.

The estimated number and volumes of waste injected into groundwater are given in Figure 10.6. The data are best estimates only. As the UIC program is implemented these estimates will be improved, particularly for Classes IV and V. Injection wells in Classes II and V account for about 97 percent of the total wells and 90-95 and 3 percent of the volume, respectively. The Class I wells make up less than 1 percent of the total number of wells but inject 1 to 5 percent of the volume.



*In addition to injection wells used in oil and gas operations there are an estimated 2 million producing or abandoned wells which would be affected by the UIC regulations under the area of review concept.

Sources: Temple, Barker and Sloane, Inc.(1978); Arthur D. Little, Inc. (1979); Geraghty and Miller (1978); Hartley (1978)

Figure 10.6 USE OF INJECTION WELLS IN 1979

The number of the operating and drilled Class I wells by state is shown in Figure 10.7. The wells are concentrated in the Gulf states and the southern Great Lakes region. The states not shown as needing a UIC program will be included either in May, 1979 or May, 1980. Most of the Class II wells are located in the major oil producing states (see Figure 10.2 for the number of brine disposal wells per state). The wells used for enhanced recovery and hydrocarbon storage occur primarily in California, Kansas, Kentucky, Oklahoma, and Texas (ADL, 1979). Solution mining wells are used for uranium, copper, sulfur, salt, and potash. Most of these wells are located in Louisiana, Michigan, Texas, and Wyoming. Geothermal injection wells are presently located in California, Idaho, and New Mexico. Development in other states may occur in the next few years including Hawaii, Maryland, Nevada, and Oregon. Class IV and V wells occur throughout the country but specific locations are not known at present.

Contamination from underground injection operations depends on site, well, and waste characteristics and varies from one class to another. The discussion of type of contamination from oil and gas operations and municipal waste in earlier sections pointed out that the pollutants are mostly constituents included in the secondary drinking water standards (e.g., chlorides, TDS). The pollutants from industrial and mining activities include these constituents as well as a variety of heavy metals and toxic substances (Table X-6). Whether these substances will reach an aquifer depends partly on the behavior of the constituent in the soil and formation material. A general indication of the mobility of some constituents is also shown in Table X-6. A waste disposal operation which is sited and constructed with the soil characteristics in mind may minimize the potential contamination. Other factors influencing the contamination potential from injection wells are the mechanical integrity of the well, whether freshwater zones are cased off and cemented, and whether the fluid is injected under pressure or not. The proposed UIC regulations will include specifications on well construction and cementing designed to minimize the contamination potential.

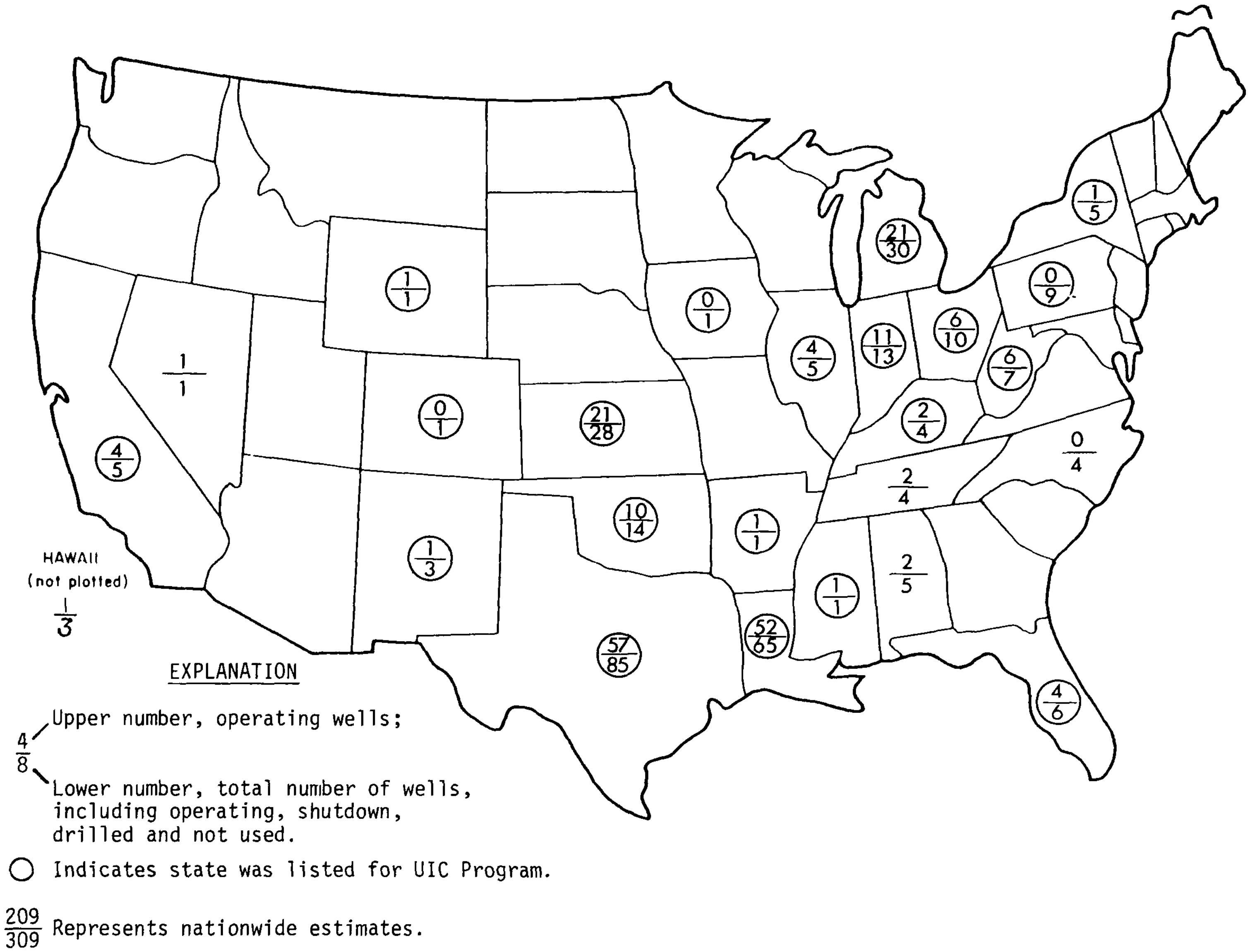


Figure 10.7 LOCATION OF CLASS I INJECTION WELLS BY STATE

Source: Reeder, et al. (1977) and Temple, Barker and Sloane (1978).

Table X-6

SELECTED WASTE COMPONENTS BY INDUSTRY

	Metals Mining	Primary Metals	Pharmaceuticals	Inorganic Chemicals	Organic Chemicals	Plastics	Paints	Petroleum Refining	Paper
Ammonium Salts		X				X		X	X
Antimony	X			X			X		
Arsenic**	X	X	X	X				X	
Asbestos**	X			X			X		
Barium							X		
Beryllium	X							X	
Biological Waste			X		X				X
Cadmium+,**	X	X		X			X	X	
Chlor. Hydrocarbons**				X	X		X		
Chromium**	X	X	X	X			X	X	
Cobalt**							X	X	
Copper**	X	X	X				X	X	
Cyanide	X	X		X	X	X		X	
Fluoride**	X	X		X					
Lead**	X	X		X			X	X	
Magnesium**	X								
Manganese**	X	X							
Mercury+,**	X	X	X	X			X	X	
Molybdenum	X							X	
Nickel**	X	X		X				X	
Oil		X						X	X
Organics, misc.**					X				
Pesticides (organo-phosphates)**									X
Phenol	X	X		X	X	X		X	X
Phosphorus++	X			X	X	X		X	X
Radium**	X								
Selenium**	X	X	X					X	
Silver**,+	X							X	
Vanadium	X							X	
Zinc+,**	X	X	X	X		X	X	X	
Sulfer**	X			X		X		X	X
Nitrogen*	X					X		X	X
Chloride*	X			X				X	
Total Dissolved Solids*	X	X	X	X	X	X	X	X	X

*Mobile constituent in soils

**Attenuated by adsorption on clays, organics or Fe, Al compounds

+Forms complexes (e.g., Cl)

++Irreversibly bound to soil.

Source: Geraghty and Miller (1978); EPA (1977c); Summers, et. al.(1979)

Specific contamination cases were described in several reports involving cesspools, brine disposal wells, abandoned mines, sewage disposal wells, storm runoff recharge wells, air-conditioning wells, industrial waste disposal wells, and pesticide disposal (Geraghty and Miller and Temple, Barker and Sloane, 1978; and EPA, 1977c).

d. Nonpoint Sources

Contamination of aquifers also occurs from nonpoint sources including agriculture, mining, silviculture, construction, urban runoff, residential septic systems, highway salting and storage facilities. These sources and ways to control them were discussed in Part 1. Results of a survey of 809 contamination cases by the USGS in all 50 states showing the breakdown by source are presented in Table X-7.

Table X-7

SURVEY OF AQUIFER CONTAMINATION BY NONPOINT SOURCES

Source of Contamination		Percent of Contamination Cases
Mine Drainage		2
Runoff		5
Agriculture		6
Spills & Leaks		12
Highway Salt		6
Abandoned Wells		10
	Subtotal	41
Point sources		45
Saltwater intrusion		14
	Total	100

Source: EPA (1977c)

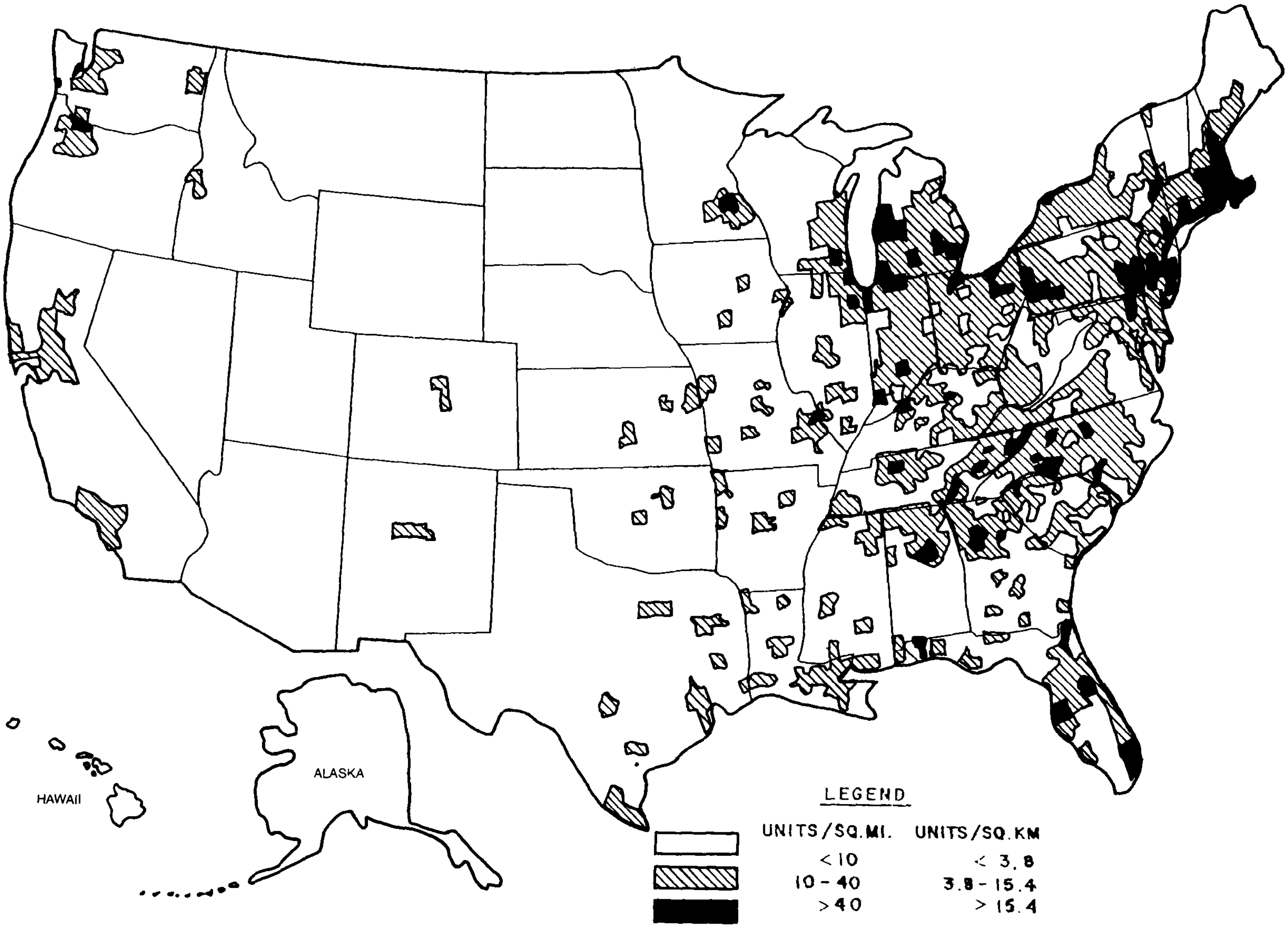
Some of the problems caused by abandoned wells and mines will be covered by the UIC program. The Areawide Waste Management (Section 208, PL 92-500) programs addressed nonpoint sources in some areas including Long Island which will be discussed in the case histories section.

Contamination from septic systems has resulted in some areas changing to sewer systems and wastewater treatment plants. The number of domestic septic systems is estimated to be 2 million (Metcalf and Eddy, 1979). The location of domestic systems at densities greater than 10 units per square mile is shown in Figure 10.8. Most of the areas with high densities are located in the east with a few areas in California, Oregon, and Washington. Rural and small town populations throughout the country are also using individual septic systems. The total population served by these systems is presently about 29 percent.

Contamination problems occur mostly in areas of very permeable aquifers such as sand and gravel and where densities are high. In the case of Long Island over a million people were served by septic systems and the shallow glacial aquifer composed of sand and gravel was contaminated by nitrate. The Old Colony Planning Council in Massachusetts investigated the nitrate contamination under their 208 program and determined that individual septic systems would not be a problem if the number of systems was restricted to a single unit per one-half to one acre. Local contamination problems may occur in areas with individual water supply wells if the groundwater flow directions are not considered when the well and septic system are constructed. A new manual on construction and use of septic systems is due to be published by EPA this year.

3. Surface Water Interactions

Ground and surface waters may have both quantity and quality interactions. Quantity interactions include direct exchange with unconfined aquifers and exchange in the recharge area of confined aquifers. The flow direction depends on the difference in water elevation between the groundwater level and the depth of water in the river if the two are hydraulically-connected. If the groundwater level is below the river



after EPA, 1977c

Figure 10.8 LOCATION OF DOMESTIC SEPTIC SYSTEMS bottom (no hydraulic connection) the water in the river may seep through the bottom sediments where the permeability is not too low. Surface water can also be used to artifically recharge the groundwater through basins, spreading areas, or injection wells. In some areas stormwater runoff is used for this purpose which can affect the quality if high concentrations of metals, fertilizers, pesticides or other pollutants are present.

Another quantity interaction is caused by heavy pumping of groundwater in the vicinity of a stream. The cone of depression of the well may expand to intersect the stream causing surface water to enter the well. If this surface water is contaminated, the water quality of the aquifer will be degraded. In some states this situation may not be stopped because the allocation systems and water rights laws are different for ground and surface waters. Colorado law has a tributary groundwater definition which protects the groundwater that flows to the stream (i.e., baseflow). Decreased streamflow may occur after sewering an area if the recharge from septic systems is large as happened in Nassau County, Long Island (Cohen, et al, 1968).

Quality interactions take place in the instances cited above. If either the surface or groundwater contains high concentrations of pollutants, quality in the other source will be affected. In some areas there may be seasonal water quality changes depending on the percentages of baseflow and runoff. Landfills and dumps located in floodplains may contaminate the surface water during floods. The surface water may later contaminate the groundwater through recharge. Contamination of the Biscayne aquifer in Florida occurred due to seepage from canals carrying saltwater (Newport, 1977). In the Rathdrum Valley aquifer in Spokane some contamination has occurred due to recharge from surface water containing mine drainage and septic waste.

These types of interactions may occur in alluvial river valleys and near lakes and ponds. The location of the major river valleys where groundwater can be recharged by the rivers is shown in Figure 10.9. The major valley aquifers are in the Northeast and Central regions. In the glaciated part of the country these valleys are composed mostly of sand

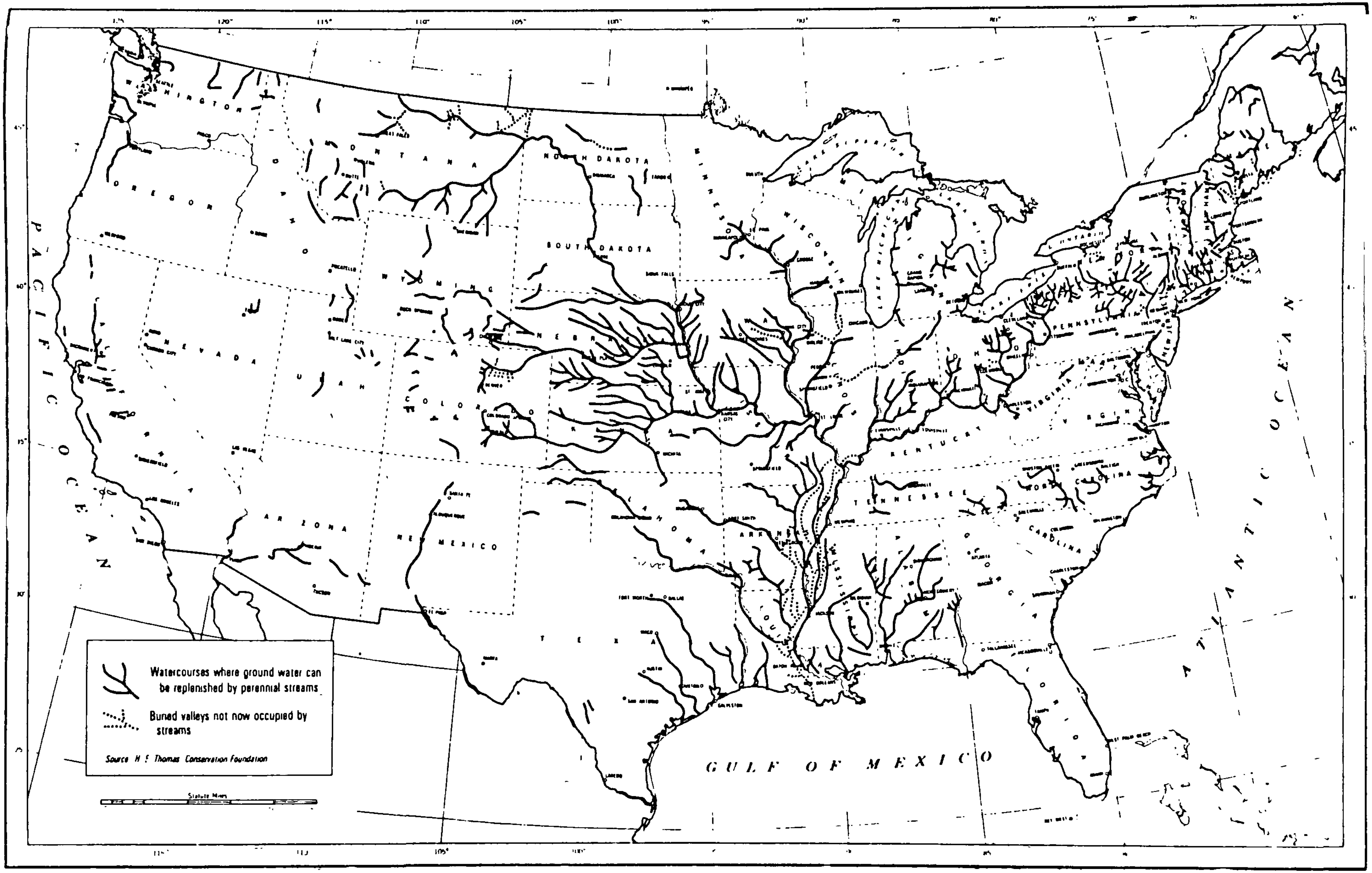


FIGURE 10.9 LOCATION OF RIVER VALLEY AQUIFERS

Source: W.H. Thomas Conservation Foundation from Geraghty, <u>et al</u>. (1973)

and gravel which can yield large volumes of water but are easily contaminated. In the Central region the valley aquifers are composed of thick alluvial sequences of sand, silt, and clay which do not yield such large volumes of water. In areas where the regional groundwater movement is toward a stream the surface water will also be affected.

4. Impact of Problems on Drinking Water

The descriptions of quantity and quality problems in the above sections show that drinking water supplies are affected by overdraft, waste disposal, and surface water interactions. Figure 10.10 compares the areas impacted most by these problems with the usage of groundwater by region. The map shows the percent of total withdrawals supplied by groundwater along with the population using this source for drinking water. Three regions have the highest potential for contamination -- California, Florida, and the southwest-Gulf states of Texas, Oklahoma, Louisiana, New Mexico,Mississippi and parts of Kansas and Arkansas. More than 90 percent of the population in Florida, New Mexico and Mississippi use groundwater as a source of drinking water. More than 60 percent of the populations in the remaining states except California (46 percent) use groundwater as a source of drinking water. The southern Great Lakes region has a high potential for contamination and the percent of the populations served by groundwater ranges between 30 and 60 percent. As previously noted, California, Florida and southwest-Gulf states are also subject to saline water intrusion problems (see Figure 10.1).

The existing legislative and administrative control measures and applicable laws are reviewed in Part 1 and summarized in Table X-8. These measures ensure some protection and will result in less quality degradation. The permit processes can offer more protection if the requirements are based on technical considerations such as soil characteristics and depth to groundwater. The permit processes can also be used to require or encourage use of technical control measures such as liners and casing. Inspection of the permitted facilities is often not done and would ensure that the procedures were followed.

Table X-8

LEGISLATIVE AND ADMINISTRATIVE CONTROL MEASURES

Problem	Agency	Measure	Status
Saltwater Intrusion	State/Local	Management	21 cases/43 states
Surface Impoundments	Federal	State Assessment (SDWA)	To be completed 1980
	Federal	RCRA Permits	Regulations proposed
	State	NPDES Permits	32 States
Landfills, Dumps	Federal	RCRA Permits Close open Dumps	Regulations proposed 5 years after inventory
	State	Permits	44 States
Injection Wells	Federal	UIC Permits	Regulations proposed
	State	Well Regulations	43 States
Feedlots	Fed/State	NPDES Permits	Large lots only
Septic Systems	Federal	RCRA Permits- New	Multi-dwelling only Regulations proposed
	State/Local	Permits	Most States
POTW (pipes)	Fed/State	CWA 201, NPDES Permits	All States
Mining	Federal	Surface Mining Act	Regulations proposed
	Fed/State	NPDES Permits	All States

In addition to the permit type programs other measures have been used to minimize quantity and quality problems. These include designating areas as groundwater management districts or critical areas, or prohibiting waste disposal operations in aquifer recharge zones. The next section describes several examples.

C. Case Histories

Several case histories are selected to illustrate some of the management programs that have been used. Groundwater management has helped to solve some quantity and quality problems. The methods include regional water supply planning, local planning, 208 Areawide Wastewater Management planning, and the Sole Source Aquifer Program of the Safe Drinking Water Act. The case histories and major programs that were implemented are identified below:

- Quantity Problems
  - San Bernardino, California - State/Local Planning
  - Fresno, California - Integrated Surface/Groundwater Management
  - Northeast Illinois - Regional Water Supply Planning
- Quality Problems
  - Edwards Underground Reservoir, Texas - Sole Source Aquifer
  - Long Island, New York - Sole Source/208

For each case history a brief description of the problem is given together with the management program and implementation mechanism selected. . . . .

1. Quantity Problems

a. San Bernardino Valley, California

The San Bernardino Valley of California is located in a semi-arid region approximately 60 miles east of Los Angeles. In 1954, the San Bernardino Valley Municipal Water District (SBVMWD) was organized to plan for a long-range water supply for the San Bernardino area. The district's total population was about 316,000 in 1970 and is expected to increase to 690,000 by 1990.

The principal water supply source for this area is an extensive groundwater aquifer ranging in thickness from 100 to 1200 feet. In 1960, locally pumped groundwater supplied nearly 80 percent of the water demand of the region (California DWR, 1970). The aquifer in this region is alluvium consisting largely of sand, gravel, and boulders interspersed with lenticular silt and clay deposits. Moreover, the aquifer is cut by a complex system of faults and barriers across which the flow of groundwater is generally restricted. Extensive pumping has resulted in serious overdraft of the groundwater basin. Since about 1945, water levels have declined more than 100 feet and formerly swampy lands have dried up and are now highly urbanized (Hardt & Hutchinson, 1978). This dramatic decline in water levels has caused additional problems of land subsidence. Groundwater quality problems also occur in some areas of the San Bernardino Valley as nitrate concentrations (NO_3-N) above 10 mg/l are found in some water supply wells. The probable sources of this nitrate include fertilizer used for citrus and field crops, and artificial recharge of sewage effluent discharged either to sewage lagoons or to the Santa Ana River (USGS, 1977).

To alleviate the depletion of local groundwater supplies, the SBVMWD contracted with the California Department of Water Resources for an annual entitlement of 48,000 acre-feet of California Aqueduct water beginning in 1973 and increasing to 102,000 acre-feet by 1990. Annual deliveries from 1973 to 1976 averaged about 1,800 acre-feet (Hardt and Hutchinson, 1978). The 208 plan for this area considered the impacts of artificial recharge of imported water. The recharge of imported Northern California water may cause groundwater levels to rise again in the area that was formerly a swamp. This may cause structural damage to building foundations. Accordingly, the SBVMWD has contracted with various consultants to study the detailed relationshp between artificial recharge and aquifer response. It is hoped that management alternatives, such as varying recharge location, distribution, and amount can be identified which would avoid excessive water level rises.

Nitrogen fertilizer application has been significantly reduced in recent years due to the implementation of better agricultural management practices. Section 201 facilities plans currently being formulated may identify ways to reduce nitrate inputs to the groundwater basin arising from recharge of sewage effluent.

b. Fresno Irrigation District, California

Fresno Irrigation District was formed in 1920 as a successor to a company which had been diverting water from Kings River since 1871. The District's rights to Kings River water average about 415,000 acre-feet (AF) per year. In addition, the District has a contract with the U.S. Bureau of Reclamation for 75,000 AF of water. The average annual supply of Federal Central Valley Project (CVP) water is presently 64,000 AF of which 60,000 AF goes to the City of Fresno. Neither the City of Fresno, the water works districts, nor the City of Clovis have treatment facilities to enable the direct use of surface water for drinking. The District contains approximately 245,000 acres which is essentially fully developed in a wide variety of high revenue crops and urban and suburban lands. About 160,000 acres (or 65 percent) of this land receive surface water. Available surface water is supplemented by private pumping for irrigation use. The District does not provide direct service to urban and suburban entities.

Substantial urbanization has occurred in the District since 1945 and it now has a population estimated at more than 300,000 people. All water served by Fresno, Clovis, and the county water works districts serving unincorporated areas, is supplied from groundwater sources. As a result of heavy concentrations of pumping, particularly by the City of Fresno, a substantial cone of depression developed. This adverse condition led to the establishment of a cooperative water resource management plan between the District and the City of Fresno.

An extensive water resource management program has been developed through the cooperative efforts of the Fresno Irrigation District, City of Fresno, City of Clovis, 15 county water works districts, and the Fresno Metropolitan Flood Control District (San Joaquin Valley Agricultural Commission, 1979). The program involves the integrated use of surface and groundwater, storm water control, and wastewater management in an area where productive agricultural land is undergoing urbanization.

The District delivers about 15,000 AF of the City of Fresno's supply of CVP water to an artificial recharge basin in the Fresno Metropolitan area. This basin (117 acres) overlies the cone of depression previously created by overpumping of city wells. Additionally, the District provides surface water to locations which would benefit from recharge (i.e., decrease withdrawal rates, or increase groundwater supplies). A similar arrangement is performed with the City of Clovis utilizing a 70-acre artificial recharge basin owned and operated by that city. Through these cooperative efforts, an efficient combined-use operation is maintained, eliminating the necessity for construction of expensive water treatment and duplicate conveyance facilities. The District also cooperates with the Fresno Metropolitan Flood Control District by utilizing (during the irrigation season) five artificial recharge basins constructed by the Flood Control District for the percolation of storm water during the rainy season. Plans include the addition of recharge basins to the program as funds become available.

Of particular interest is the cooperative arrangement between Fresno Irrigation District and the City of Fresno regarding wastewater management and reclamation. Wastewaters, including winery stillage wastes subject to secondary treatment, are discharged to a 2,000 acre infiltration bed which percolate to groundwater thereby effecting tertiary treatment. The City extracts groundwater from beneath the infiltration beds through a series of 21 wells which discharge into the Fresno Irrigation District canal system. In turn, for each two acre-feet of water pumped into the District canal system by the City, the District furnishes about one acre-foot of fresh water from its surface supplies. This water is delivered to the eastern portion of the District and in areas that can best use it to recharge the City's groundwater supply. In 1978, enabling state legislation provided a means by which charges could be levied on lands undergoing urbanization to generate funds for recharge facilities. This bill (SB 2046) was supported by and will benefit the District and City of Fresno in their continuing cooperative programs.

c. Northeastern Illinois Regional Water Supply Plan

The Northeastern Illinois Planning Commission (NIPC) area includes six metropolitan and suburban counties in the Chicago metropolitan area: Cook, DuPage, Lake, Will, Kane, and McHenry counties, Illinois. NIPC has estimated that these counties will grow from a current population in excess of seven million to over nine million people by the year 2010 (Keifer, et al., 1979). About 200 communities in NIPC's six-county planning area now rely on two major sources for their domestic water supply: (1) surface water from Lake Michigan, and (2) groundwater from both the deep and shallow aquifer systems of the region. Neither source is unlimited. The amount of water Illinois can divert from Lake Michigan was limited to 3,200 cubic feet per second (cfs) by a 1967 U.S. Supreme Court decree (U.S. Supreme Court, 1967). The City of Chicago, 74 adjacent communities, and 36 other entities now utilize 1,739 cfs of the total, 54 percent of Illinois' allotment. Other uses that account for the remaining 1,461 cfs includes lockage flows, water lost as leakage through three controlling structures on the Chicago River System, navigational make-up, discretionary diversion water for maintenance of water quality standards in the Chicago River System, and storm water runoff. There is little likelihood that new water users can be supplied with lake water, unless the volume demand for one or more of the existing Lake Michigan water uses is modified (Keifer, et al., 1979).

The remaining communities rely on groundwater. Groundwater resources are developed from four systems: (1) sand and gravel aquifers of the glacial drift; (2) shallow dolomite aquifers of Silurian and Ordovician age; (3) the Cambrian-Ordovician Aquifer, of which the Ironton-Galesville and Glenwood - St. Peter Sandstones are the most productive formations; and (4) the Mt. Simon Aquifer which consists of sandstone beds of the Mt. Simon and Eau Claire Formations of Cambrian age (Suter, et al., 1959; Walton, 1970). More than half of the supply from groundwater sources comes from the deep sandstone aquifers (3) and (4) above. This source, although widely productive, often contains high mineral contents which require costly treatment practices. Pumpage of the deep sandstone aquifer has exceeded recharge for nearly 20 years with recent data indicating that water withdrawal rates are three times greater than replenishment rates (ISWS, 1976). Some communities rely on the shallow aquifer systems which are very site-specific and not widely productive at yields required for municipal water supply despite having large estimated volumes of water available. Also, extreme variation in mineral content of this shallow source in some areas makes costly treatment necessary. In 1974 pumpage rates from the shallow aquifer were only one-fourth of its estimated potential yield (ISWS, 1976).

These limitations on current water supplies together with the projected growth increases of Northeastern Illinois prompted the development of a long-range water supply plan to ensure an adequate future supply of water for this large metropolitan area. A planning study was conducted by Keifer and Associates, Inc. for the NIPC through an urban planning grant from the Department of Housing and Urban Development. Development of the regional water supply plan was based on a set of technical planning policies, grouped into four specific areas of concern; (1) use of Lake Michigan water, (2) use of groundwater supplies, (3) use of inland surface water supplies, and (4) general management of water resources.

A digital computer model was developed to determine the apparent cost-effective sources of water supply for each entity in the six-county study area. Evaluations were made of nine different scenarios, which examined the various alternatives for utilizing the four available supply sources. Using the technical planning policies for guidance and the computer modeling results, a preliminary regional water supply plan was developed to meet the 2010 water demands for the six-county area. The plan includes eight regional systems which are supplied with water from the available surface waters and other areas served by groundwater.

2. Quality Problems

a. Edwards Underground Reservoir

The Edwards Underground Reservoir is located in South Central Texas. The Edwards Aquifer lies within the physiographic provinces of the Edwards Plateau and Western Gulf Coastal Plain, which are separated along the Balcones fault zone. The aquifer is the sole source of supply for about one million people in San Antonio and surrounding cities and towns. In addition, discharges from this aquifer provide a substantial amount of the base flow of the major river systems of the region (U.S. Army Corps of Engineers, 1973).

The Edwards Underground Reservoir is an extremely fractured and cavernous limestone aquifer, having a major water-bearing thickness varying from 350 to 550 feet. Two distinct groundwater aquifers can be identified, an unconfined zone in the Edwards Plateau through which most of the recharge enters and an artesian aquifer in the Balcones fault zone. The southern limit of the aquifer is an imaginary "bad water line" beyond which the groundwater contains excessive amounts of hydrogen sulfide and total dissolved solids.

The groundwater quality in the Edwards Underground Reservoir is generally very good, aside from the moderate levels of hardness to be expected in a limestone aquifer. However, there is some evidence of temporary groundwater quality degradation in the recharge zone of the unconfined portion of the aquifer following storm periods. In these cases, moderate levels of turbidity, coliforms, and pesticides have been observed. Such water quality changes indicate that the Edwards Aquifer is vulnerable to pollution through its recharge zone. Water migration through limestone aquifers occurs primarily through solution channels and caverns. Hence, once introduced into the aquifer, pollutants may travel rapidly with little attenuation.

Because of the extreme importance of the Edwards aquifer as a water supply and its high vulnerability to contamination, a coalition of local interest groups petitioned the EPA Administrator to designate the Edwards Underground Reservoir as a sole source aquifer under the provisions of Section 1424(e) of the Safe Drinking Water Act. This designation provided a means by which this critical groundwater source could receive special attention and protection. In 1975, the Edwards Underground Reservoir became the first of the sole source aquifer designations.

b. Long Island Groundwater

"Groundwater beneath Nassau and Suffolk Counties is the only source of fresh water supply for almost three million people. The quality and quantity of this water is modified by regional and local water supply development policies and waste disposal practices" (Nassau-Suffolk Regional Planning Board, 1978 p. 5).

Two main water bearing units, the Upper Glacial and Magothy aquifers, are the principal sources of water supply. The Lloyd aquifer, a relatively unexploited source of water, lies beneath these two upper formations. The three aquifers combined contain over 60 trillion gallons of water (Cohen, et al., 1968). There is not a problem with total available supply although the uneven distribution of withdrawals has created localized problems. Contamination of the groundwater has resulted from a variety of sources including systems designed to discharge to the ground (septic tanks, sewage treatment plant effluent, industrial waste discharges, storm water recharge basins, incinerator quench water, and scavenger waste disposal). In addition, a number of other activities such as landfill leaching, sanitary sewer leaking, animal wastes, cemetaries, highway deicing, sand and gravel mining, use of fertilizers and pesticides, and spills and leakage contribute to pollution of the groundwater.

Contamination of the groundwater, particularly the Upper Glacial aquifer has been observed. Nitrate-nitrogen concentrations have increased, although in most cases concentrations are still below the 10 mg/l standard. Heavy metals are widespread in the shallow groundwater although concentrations are generally below Primary Drinking Water Standards. Enteric viruses were not found in a brief study of water supply wells. Organic chemicals, including substituted benzene compounds, napthalenes and various butylphtalates were found during special studies conducted as part of the 208 program. Partly as a result of potential contamination, many of the shallow wells have been abandoned in favor of less vulnerable supplies from deeper aquifers.

Long Island also exhibits close interactions between ground and surface waters. The island has numerous perennial streams which are largely groundwater fed. The stream habitat as well as the salinity regime of the bays is largely dependent on these flows. Therefore practices which affect the elevation of the groundwater table can have a marked effect on both stream and bay ecology.

In general, groundwater has "not been developed according to any scientific plan or long-term program with the objectives of protecting water quality, maximizing the available resource, or minimizing the impact on streams or bays" (Nassau-Suffolk Regional Planning Board, 1978). The Nassau-Suffolk 208 program (1978) has found that fragmentation of responsibility among numerous water supply units which are controlled by local economic and political factors has hindered adoption of water management proposals. The planning board further concluded that water and waste management schemes can be most effectively implemented if decisions are approached on an island-wide basis.

The Nassau-Suffolk 208 program developed and analyzed a large number of wastewater management alternatives. From these a set of "pre0 ferred plan alternatives" was recommended. The preferred alternatives include measures for control of stormwater runoff, proper functioning of on-lot waste disposal systems, reduction of fertilizer usage, reduction of landfill pollution, control of animal wastes, control of industrial waste, product storage and transportation, promotion of water conservation, and development of alternatives to ocean disposal of municipal sludge.

The plans include, for the most part, nonstructural measures and call for the institution or continuation of Best Management Practices. The plans include monitoring and demonstration programs.

Existing county and state agencies are now implementing many monitoring, regulatory, and operational waste treatment programs. Some land use controls currently exist but nonpoint source control is weak. Although, all the necessary agencies to implement the 208 plan now exist, there are a number of options for organization and responsibility. For example, water production and supply in Nassau County are currently managed by 46 separate independent water companies.

The Nassau-Suffolk Regional Planning Board (1978) has recommended that specific county and state agencies be assigned responsibility for various facets of operations, management, and planning.

D. Major Findings

The findings of this chapter are intended to point out major quantity and quality problems and some observations on the management and control programs currently in use. Potential changes are discussed in Part 3. The major findings are:

- Groundwater is the source of drinking water for about 47 percent of the Nation's population including 95 percent of it's rural population. It is commonly less costly to develop than surface water and is usually pure enough for drinking with minimum treatment.

- The most common quantity problem with respect to groundwater results from overdraft or mining of the source. As long as the quantity removed from an aquifer each year is equal to or less than the average recharge to the aquifer, the groundwater supply is theoretically permanent and inexhaustible. If withdrawal exceeds the recharge, the groundwater is being mined in the same sense as for all minerals and the supply progressively diminishes until the aquifer is exhausted. When overdraft ceases, recovery of the groundwater begins but in the drier areas of the country, recharge is so low that centuries will pass before the aquifer is refilled. Twenty billion gallons per day of groundwater is now being mined in the United States -- one fourth of the annual groundwater pumpage.

- Subsidence of the land with attendant disruption of overlying structures has occurred in many areas of overdraft and represents a further economic cost of groundwater mining. Subsidence also decreases the storage capacity of the aquifer.

- Lowering of the groundwater levels as a result of mining permits salt water from the oceans or from adjacent aquifers to enter an aquifer. Thus groundwater mining can cause or at least augment the pollution of the aquifer being mined.

- Groundwater has been a preferred source of drinking water because of its purity. Increasing volumes of waste are now being disposed of in ways which lead to pollution of the groundwater. Because the groundwater moves very slowly through most aquifers, many years may be required for pollution once within the aquifer to pass through the system. Unless it is economically feasible to correct the pollution problem by pumping the polluted water from the aquifer, a polluted groundwater source may be out of use for decades.

- Sources of pollution in the groundwater include:

  - Over 130,000 surface impoundments of polluted water.

  - More than 20,000 landfills and dumps handling over 500 million tons of waste annually.

  - In excess of 400,000 injection wells used to inject more than 900 bgy of wastes into the ground.

  - Nonpoint sources including agricultural and silvicultural chemicals, mining waste, residential septic tank systems, highway salting for snow control, and urban storm runoff.

- Surface impoundments are a serious problem due to the large number of sites and volumes of waste, the fact that it reaches the shallow aquifers used for drinking water supplies relatively quickly, and the presence of a head differential which can cause the waste to infiltrate faster.

- The various types of shallow injection wells present more potential for contamination of currently used drinking water supplies than the deep injection wells due to the larger numbers and less control of siting and construction for the shallow facilities.

- Recent Federal legislation has provided some authority to begin addressing the threats to groundwater quality posed by wastewater disposal practices. In particular, Under-Injection Control regulations recently proposed will address injection wells. A surface impoundments inventory and assessment is being conducted, and the Resources Conservation and Recovery Act provides a basis for controlling those which contain hazardous wastes.

Dumps and landfills will also be controlled under this Act. Both the Sole Source Aquifer provision of the Safe Drinking Water Act and 208 planning under the Clean Water Act provide additional management opportunities. EPA is fully committed to implementing these management tools in cooperation with the states; implementation is now in its preliminary phases. Thus it is too early for a detailed evaluation of results. Additional Congressional involvement will undoubtedly be needed a implementation difficulties are encountered.

- Regulation of groundwater mining falls within the authority of the states to establish water law. Many states have no laws specifically regulating the use of groundwater and where such laws exist, vigor of enforcement varies. Strong special interests tend to resist any effort to more intensively manage groundwater as a fragile and renewable resource.

- Both groundwater quality and quantity are neglected by most governmental units in terms of data, analysis, protection from degradation and regulation of use. The interrelationships between quality and quantity aspects of ground and surface waters are usually ignored. Although some political units have addressed groundwater management where water supply is short or the quality of existing supplies is poor, this is the exception. It is expected that groundwater management and integration with surface water programs will be a topic for increasing congressional attention.

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Chapter XI

SMALL WATER SUPPLY SYSTEMS

A. Introduction

The assessment section of this report indicates that providing an adequate and dependable supply of safe drinking water at the local level in small water supply systems is a critical problem nationwide. The objective of this chapter is to focus on the types and extent of problems experienced by small water systems; examine why the problems can be more severe on these systems; review the currently available assistance programs; and present several findings.

B. Profile of Small Systems

To place the problems of small water systems in perspective, the brief discussion of the water supply industry in the U.S. presented in Chapter VI is expanded. For this discussion, municipal or domestic water supply systems are divided into the four categories shown in Table XI-1. The first three categories are all public water systems having at least 15 connections or serving at least 25 people regularly, as defined and covered by the Safe Drinking Water Act. The National Interim Primary Drinking Water Regulations (IPDWR) subdivide public systems into community and noncommunity systems. Community systems serve permanent or year-round residents while noncommunity systems serve their "regular" customers at least 60 days per year. The remaining systems are classified as rural and consist principally of individual wells serving one or a few residences.

Community water systems are further subdivided into two size categories: small, serving less than 10,000 people, and medium-large, serving more than 10,000 people. This cut-off is the upper eligibility level for rural water and sewer development funding under the Farmers Home Administration (FmHA) and does not necessarily represent a distinct change in the severity of problems encountered. The severity of problems between a system serving 9,500 persons and one serving 100 may be much greater than between the former and one serving 15,000. The The definition, therefore, must be recognized as somewhat arbitrary for any given water system, and is used primarily to provide a general basis of comparison.

Table XI-1

DISTRIBUTION BY WATER SYSTEM CATEGORY OF POPULATIONS SERVED, MAXIMUM USE, AND NUMBER OF SYSTEMS, 1978

Category	Estimated permanent population served, millions	Maximum daily use, persons, millions	Number of systems[c]
Public systems			
Medium large community systems (>10,000 served)	161[a]	176	3,000
Small community systems (<10,000 served)	34[a]	39	58,000
Noncommunity systems	--	10[b]	160,000
Rural systems	23	23	Unknown

a. Extrapolated from Temple, Barker, and Sloane, 1977.
b. Adapted from Energy Resources Co., 1975, Appendix B.
c. Federal Reporting Data System, April 1979.

1. Population Served and Number of Systems

As shown in Table XI-1, an estimated 57 million people, or about 25 percent of the national population, are served by small or rural water systems. Of these, approximately 34 million people are served by community water supply systems. The estimate of 23 million people served by rural systems is derived by subtracting the estimate of population served by community systems in a recent survey (Temple, Barker, and Sloane, 1977) from the estimated total national population. This estimate is lower than some others -- e.g., 33 million (WRC, 1978) and 36.4 million (SCS, 1975); therefore, the exact number is uncertain.

In the latter study it was estimated that only 177 million people were served by community systems, referred to as central systems in the study.

The estimate of maximum daily use in Table XI-1 represents the permanent population served plus the maximum seasonal and transient population that might be served daily. In the aggregate, community systems serve 10 to 15 percent additional transient population at peak periods, although the national totals tend to mask the local impact of seasonal populations, particularly in resort areas. The seasonal population may actually be greater than the permanent population served by some small community systems (Temple, Barker, and Sloane, 1977). The most dramatic statistic is the large maximum daily use of noncommunity systems that serve a very small permanent population. These include systems serving parks, campgrounds, motels, restaurants, and industrial, institutional, and commercial establishments with their own water supply. The estimate of 10 million people is calculated from data contained in a previous study (Energy Resources Co., 1975) but is approximate and probably conservative. Recent preliminary estimates reported by states (FRDS, 1979) have indicated a total as high as 97 million served by noncommunity systems, but this figure probably includes both daily and total annual estimates.

Although about 75 percent of the population is served by medium-large public systems, small water systems account for 95 percent of the number of community systems. Furthermore, the number of noncommunity systems is more than twice the number of community systems, and the number of rural systems is a much greater, though unquantified number. Thus, relatively few systems serve much of the population, and a vastly greater number serve the remaining 25 percent.

While it is recognized that a significant population is served by rural systems, this report will focus mainly on public water systems that are regulated under the Safe Drinking Water Act. The problems and needs of rural water systems are being addressed in detail as part of the Rural Water Survey currently underway in response to Section 3 of the Act.

2. Regional Distribution

Small water supply systems are distributed nationally, as shown in Figure 11.1. Differences in the number of systems reflect primarily the total population distribution between the regions. The figure does not reflect that small community systems represent a uniformly high percentage -- i.e. 93 to 97 percent -- of total community systems in all regions.

3. Source of Water

The predominant source of water for small systems is groundwater, as shown in Table XI-2. Over 90 percent of the systems serving less than 100 people use groundwater as a primary source, and over 85 percent of all small systems use groundwater either directly or as a purchased supply. Noncommunity systems also rely heavily on groundwater; data compiled from a number of sources (Energy Resources Co., 1975) indicate that close to 90 percent of these systems used groundwater.

Table XI-2

DISTRIBUTION OF SMALL COMMUNITY WATER SYSTEMS BY PRIMARY SOURCE (Percent)

Primary source	Size of population			
	<100	100 999	1,000 - 9,999	All systems <10,000
Ground	93	84	65	84
Surface	4	7	21	8
Purchased				
Ground	1	2	3	2
Surface	2	7	11	6

Source: FRDS, April 1979.

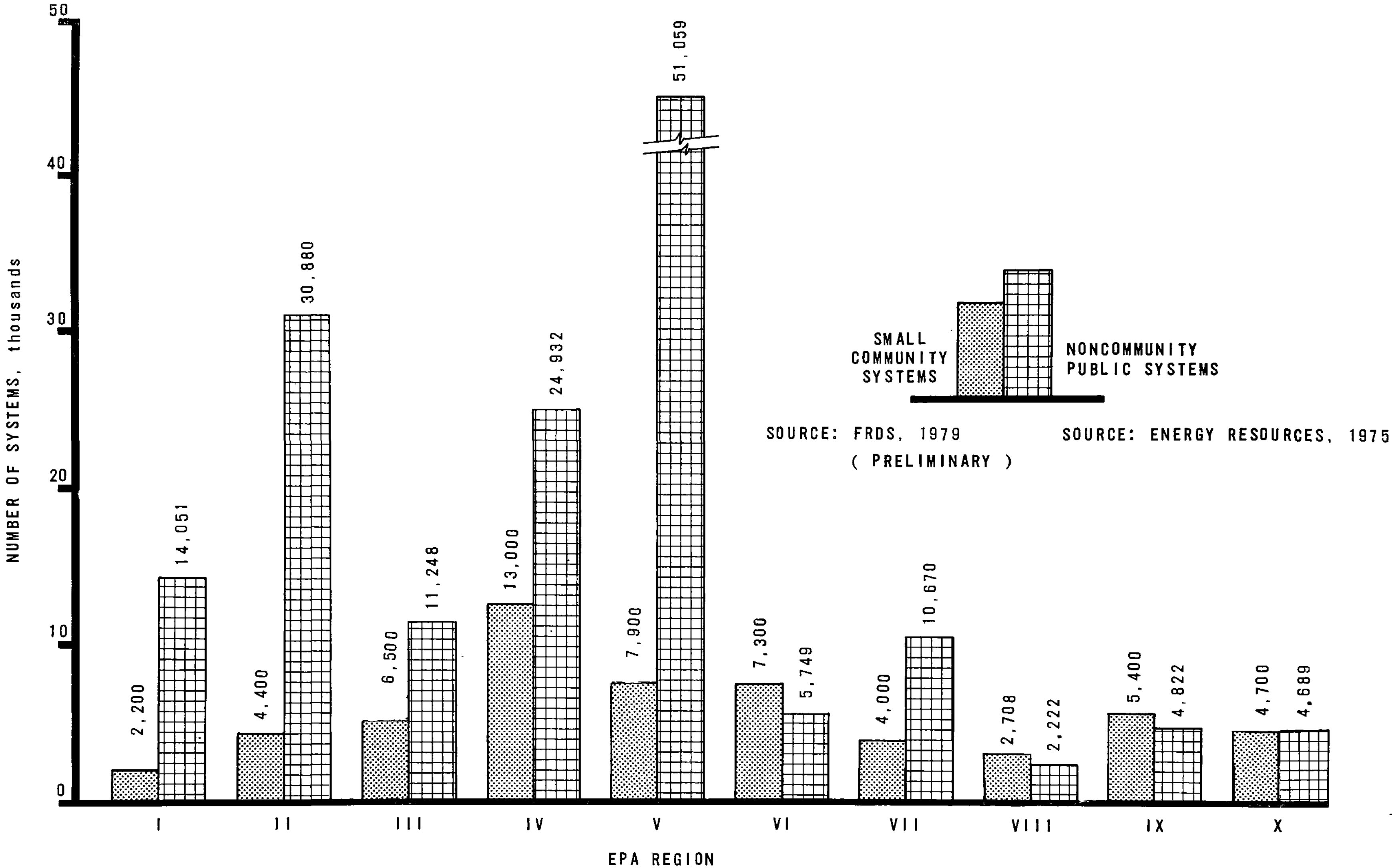


Figure 11.1 REGIONAL DISTRIBUTION OF SMALL COMMUNITY AND NONCOMMUNITY WATER SUPPLY SYSTEMS

Sources: FRDS (May,1979) and Energy Resources Co. (1975)

4. Ownership

As indicated in Table XI-3, most small water systems are publicly owned except for those serving less than 500 people. Private ownership is particularly common for those serving less than 100 people.

Table XI-3

DISTRIBUTION OF SMALL COMMUNITY
WATER SYSTEMS BY OWNERSHIP
(Percent)

	Size of population					
Ownership	25-99	100-499	500-999	1,000-2,499	2,500-4,999	5,000-9,999
Public	8	42	81	86	86	93
Private	92	58	19	14	14	7

Source: Temple, Barker, and Sloane, 1977.

C. Extent and Severity of the Problems

Two levels of analysis are used to discuss the problems that small water supply systems have in delivering an adequate and dependable supply of safe drinking water. This section presents a brief description and quantitative assessment, when possible, of performance problems; i.e., the ability to meet water quality requirements and quantity demands. . . The subsequent section analyzes some of the reasons why small systems may have more difficulty meeting the performance requirements placed on them.

1. Quality Problems

The basic measures of adequate and safe quality are the IPDWR and the Proposed Secondary Standards, as discussed in Chapter IV. As of 1978, community water systems had to monitor and report on microbiological quality for all systems, and turbidity and inorganic chemicals for surface water systems. Some compliance information is now available in the Federal Reporting Data System (FRDS) through annual State Compliance

Reports, and is the main source for this analysis. The data on groundwater quality are incomplete. The other comprehensive data are from the U.S. Public Health Service Community Water Supply Study conducted in 1969 (PHS, 1969) which reviewed compliance with recommended and mandatory limits as well as other system deficiencies for a limited number of systems.

Both maximum contaminant level (MCL) violations, and reporting and monitoring violations reported by the states, are summarized in Table XI-4. The first three categories of violations are taken directly from the information available from FRDS as of April 1979. Inorganic constituents MCL violations for groundwater systems are from a 1975 economic evaluation of the regulations (Energy Resources Co., 1975), which is based in part on data from the aforementioned Public Health Service study. Values provided in the table represent the systems violating a given requirement as a percentage of all systems in the same size and source categories. For example, 36 percent of all small systems using surface water violated the reporting and monitoring requirement.

Table XI-4

IPDWR VIOLATIONS FOR COMMUNITY WATER SYSTEMS (Percent)

	Violations, % of systems							
	All sources		Surface waters only				Groundwater only	
	Microbiological[a]		Turbidity[a]		Inorganic chemical[a]		Inorganic chemical[b]	
Size of system	MCL	Reporting and monitoring	MCL	Reporting and monitoring	MCL	Reporting and monitoring	MCL	Reporting and monitoring
Small	24	35	10	36	7	8	9	n/a
Medium-large	14	24	9	13	2	5	17	n/a

a. Federal Reporting Data System (FRDS) April 1979.

b. Adapted from Energy Resources Co., 1975, and FRDS information on surface water systems.

Some general observations can be made in view of this information. The most commonly violated standards are the microbiological MCL and monitoring requirements. Small systems show a significantly greater percentage of violations than do large systems, and over one-third of the small systems have not met the monitoring and reporting requirements. MCL violations occur in other standards for small systems, but are not as severe as microbiological violations. The violations in other standards also do not appear to exhibit a significantly higher percentage than the violations for systems in the medium-large category. On the other hand, reporting and monitoring violations for turbidity are high for small systems using surface water. Since turbidity requires daily monitoring, it is not surprising to find a large number of violations.

Another aspect of the microbiological violations is noted in Table XI-5. Approximately 30 percent of small water supply systems employ or have the capability of disinfection. However, the violation rate for systems with disinfection facilities is over 20 percent and only slightly lower than the rate for systems without disinfection facilities. This demonstrates that having the necessary treatment capability does not necessarily ensure better performance.

Table XI-5

MICROBIOLOGICAL VIOLATIONS AND DISINFECTION PRACTICES
SMALL WATER SUPPLY SYSTEMS
(Percent)

	Existing treatment capability	
	Disinfection	No disinfection
Systems having stated capability	30	70
Systems in violation (percentage of those having the stated capability)	21	25

Source: FRDS, 1979.

Another way of looking at the quality data is to estimate the relative population affected by noncomplying systems. This information can be estimated by using the violation data by system size category (Table X1-4) and the estimated mean population served by size category from a 1976 survey (Temple, Barker, and Sloane, 1977). The results are shown in Table XI-6. A sizable population is affected by small systems in violation of the drinking water standards, although, in absolute numbers, a greater total population is affected by medium and large systems in violation of standards. A much higher percentage of the population served by small systems is affected than for medium and large systems.

Table XI-6

ESTIMATES OF POPULATION AFFECTED BY IPDWR VIOLATIONS, COMMUNITY WATER SYSTEMS

	Small systems		Medium-large systems	
	Population affected		Population affected	
	Millions	%	Millions	%
Total population served	34.0	--	161.0	--
Microbiological violations[a]				
MCL	10.0	30	20.0	12
Reporting and monitoring	14.0	41	28.0	17
Turbidity violations[b]				
MCL	0.8	2	6.7	4
Reporting and monitoring	1.9	6	8.1	5
Inorganic chemical violations[b]				
MCL	0.2	<1	0.9	<1
Reporting and monitoring	0.4	1	4.0	2
Inorganic chemical violations[c]				
MCL	3.8	11	10.2	6
Reporting and monitoring	n/a	--	n/a	--

Notes: MCL = Systems violating maximum contaminant levels.
Reporting and monitoring = Systems violating reporting and monitoring requirements.
n/a = Not available.

a. All systems.

b. Surface water systems only.

c. Groundwater systems only.

Although compliance with primary regulations is the principal indicator of the safety of drinking water supplies, a number of supplies may be inadequate because they exceed one or more of the secondary or recommended standards (Note: some of these may in fact be mandatory limits in some states). As discussed in Chapter IV, high salinity is one of the most common drinking water quality problems identified in the WRC Second National Assessment, and many small systems may have this problem because they depend on groundwater. Among the systems surveyed in the Public Health Services Study (1969), about 24 percent of the systems serving less than 10,000 people exceeded recommended but not mandatory limits. However, certain constituents, such as nitrate and turbidity are now primary standards, but were considered recommended limits under the 1962 Public Health Service Drinking Water Standards when the study was conducted. Therefore, this estimate of systems and the current estimate of systems in violation of primary standards probably overlap.

Recent data on the quality of water served by noncommunity systems are not available, because initial reporting of IPDWR compliance for those systems was not required by 1978. Limited information from a number of sources has previously been compiled (Energy Resources, 1975). In that sampling of data, about 7 percent of the noncommunity systems exceeded an inorganic chemical MCL, and about 17 percent of the systems exceeded the coliform MCL.

2. Quantity Problems

As indicated in Chapter III, severe local municipal and rural domestic water supply shortages were identified in over half of the WRC subregions. Although shortages clearly occur for small systems, it is difficult to assess quantitatively the extent and severity of the problem since no national data base exists for water system needs other than the quality information discussed previously. An unpublished study by the FmHA in 1970 identified about 14,000 communities with central water systems needing enlargement or improvement, but this study does not provide an accurate or recent estimate of quantity problems specifically. The FmHA is beginning a National Rural Communities Facilities Investment Study that will attempt to quantify infrastructure needs, in 14 services, including water supply.

The shortages may reflect an inadequate source of supply to meet average or peak demands, or a lack of treatment, storage or distribution capacity to deliver the water that is needed. In many cases, an insufficient source of water results from quality or economic factors rather than a complete lack of any available water supply. That is, the costs to develop a new supply (e.g., drill a deeper well), or provide additional treatment, may be the barrier to providing the needed quantity of supply, particularly for small water systems. Inadequate distribution or storage capacity may often be the single greatest barrier to improving the overall delivery capacity of the system. The cost of constructing storage or replacing undersized distribution lines can be more expensive than increasing well capacity, for example.

Most small systems depend on groundwater, and overdrafting is occurring in many regions, as discussed in Chapter III. Declining water tables often first affect small systems that use shallow wells. Or small resort communities that depend heavily on surface water may run into problems as on the Oregon coast. The financial and technical capabilities of such systems to develop adequate surface storage to meet peak demands are limited. Thus, while the national extent of quantity problems cannot be specifically assessed, numerous examples indicate that many small systems experience water shortages.

D. Factors Affecting Problem Recognition and Correction

Deficiencies in quantity, quality, or both occur in many water supply systems and in order to solve an inadequate performance condition any water supply utility must be able to: (1) recognize that an inadequate condition exists and identify the extent of the problem, and (2) take corrective action. (A simple illustration of this process is provided in Figure 11.2.) In many cases, the corrective action will involve evaluation of alternatives -- such as between installing

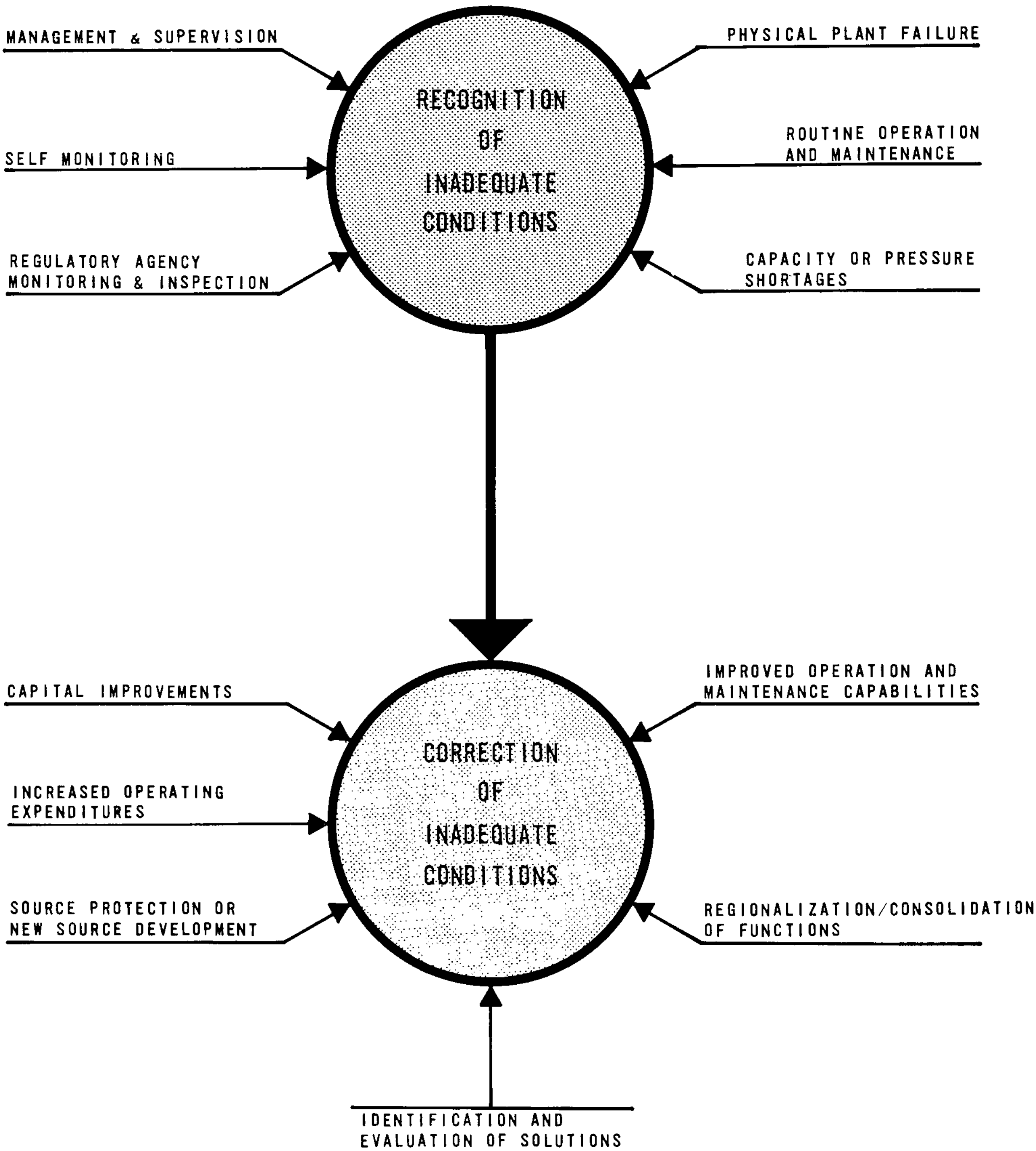


Figure 11.2 RANGE OF PROBLEM RECOGNITION AND CORRECTION MECHANISMS FOR WATER SUPPLY SYSTEMS

treatment equipment or developing a new source -- and decision making based on the outcome of such an assessment. While this process applies to all utilities, the following sections explore reasons why it can be more difficult for small systems.

1. Recognition of Inadequate Conditions

The top half of Figure 11.2 depicts several mechanisms for recognizing an inadequate performance condition. In practice timely recognition of a problem is not always as straightforward as it seems in the illustration as is discussed in the following subsections.

a. Self-Monitoring

The first level of identification of water quality problems is in routine self-monitoring. Some monitoring is required by the IPDWR, and states may establish additional requirements. However, as the data presented in Table XI-4 indicated, about 35 percent of the small systems did not properly report and monitor for the microbiological standard, and about the same percentage of small surface water systems violated the routine turbidity monitoring requirement. As presented in Table XI-4, a system is considered in violation if it fails to monitor or report, or both, on any one of its required occasions during a year, e.g., during any one month for microbiological sampling or for any one day for turbidity sampling.

A uniform monitoring requirement may be somewhat arbitrary. For systems with deep wells and well-protected aquifers, monthly sampling may be more than necessary while for other systems with real source problems, the limited number of monthly samples required may not be sufficient. However, the standard represents a reasonable minimum for most systems, and monitoring at least in conformance with these standards is a first step to recognizing quality problems.

Several factors contribute to a lack of adequate monitoring. The first is a lack of basic knowledge of the requirements. The burden of communicating as well as enforcing the monitoring requirements falls principally on the state or county health agencies or both (the difficulties these agencies face in dealing with small systems are discussed in the following section). Secondly, although most systems are probably aware of the requirements, the actual sampling and analysis may be hampered by a lack of manpower, laboratory facilities, or money.

Sampling is basically the responsibility of the individual system, although sampling by health officials may be done occasionally, for example, as part of a sanitary survey. Limited skill, knowledge, or available time by operating personnel may contribute to missed or improper sampling. Few small systems have the capability to perform tests other than possibly chlorine residual and turbidity. Thus, analyses must be done by commercial or state laboratories. Surveys taken in 1975 indicated that a number of states perform a high percentage of the inorganic analyses, and at least half of the coliform analyses (Energy Resources Co., 1975). The same study estimated that per capita monitoring costs for small systems were much higher than for larger systems.

b. Regulatory Agency Monitoring and Inspection

Quality monitoring, as well as physical inspection by state, or in some cases county agencies with responsibility for drinking water supervision, is a second means of identifying problems. States generally have programs for periodic sanitary surveys, and, in fact, are required to have a program in order to assume primary enforcement responsibility of the IPDWR. The greatest difficulty faced by many states is adequately covering the very large number of small community and noncommunity systems. For example, it has been estimated that four man-days of field time is required per system to adequately survey community systems annually (Jeffrey, 1972). While this estimate may be somewhat high, it indicates that the ideal surveillance needs for small systems would be about 230,000 man-days compared with 11,000 man-days for medium-to-large systems.

An even more basic indication of the problem of state regulation and monitoring is knowledge of the existence of systems. This is shown in the recent estimates of approximately 61,000 community water systems reported by the states as of 1979 (FRDS, 1979). This number is about 50 percent greater than the 1975 Inventory and presumably represents a more accurate assessment of how many systems exist and require regulation. Significantly, the greatest increase is in systems serving less than 100 people and 100 to 1,000 people.

c. Routine Operation and Maintenance

Routine operation and maintenance functions are another means of identifying both quality and quantity problems early. Check sampling and visual inspection of water quality, observation of available instrumentation, inspection and preventive maintenance of physical facilities are all examples. Unfortunately, the lack of sufficient manpower or skills or both has frequently been cited as a significant problem for small water systems (Johnson, 1979; EPA. 1979). The most common cause is generally inadequate operation and maintenance funding because of the diseconomies of scale discussed in Chapter VI. Small systems operate with limited and often part-time staff. In fact, volunteer labor is common in the very small, privately owned systems. Operator skill levels, particularly in terms of technical knowledge on why things are done in a particular way is significantly lower than for staffs of larger systems.

d. Physical Plant Failure or Capacity and Pressure Shortages

Chronic low pressure or capacity, or both, as well as facility failures (inoperative treatment equipment, pipeline breaks) are symptoms of system deficiencies. They are not unique to small water systems but because small systems frequently lack adequate operation and maintenance staffing or skills, such problems may go undetected for long periods. Physical correction may, therefore, be more complex and costly than if potential problems had been identified earlier.

e. Management and Supervision

In a well-staffed utility, management and supervision are important in taking overall responsibility for the specific items discussed previously. Understanding the need for, and adequately conducting, monitoring, routine operational maintenance, periodic inspections, and advanced planning is important for recognizing inadequate conditions early. Few small systems, public or private, have full-time managerial or administrative staff. Even when a small utility has an identified managerial staff (often part-time), average salaries reported for small systems are about one-half that for medium size utilities and about one-third or less the averages reported for large systems serving over 100,000 people (AWWA, 1976).

2. Correction of Inadequate Conditions

Equally important, and ultimately of greater concern is the action(s) taken to address and correct deficiencies once they have been recognized. In the following subsections some of the problems involved in achieving a solution are explored. Again, the process and problems are not unique to small systems, but the distinction is generally in the degree of capability.

a. Capital Improvements

Physical improvements to a water system are usually the most obvious solution. These may be (1) additional or upgraded treatment facilities; (2) expanded raw water delivery or well capacity (assuming additional safe yield exists); or (3) improved distribution system and storage capacity. Assuming that the specific need can be identified, justified, and designed, the major obstacle for small systems is often the financing. Diseconomies of scale have previously been mentioned in this report, but it is instructive to review some of the data in slightly different terms. In Figure 11.3, several financial characteristics of small and medium-large systems are illustrated.

As shown in the figure, typical capital expenditures for the smaller systems are more than twice as high on a gallons produced basis.

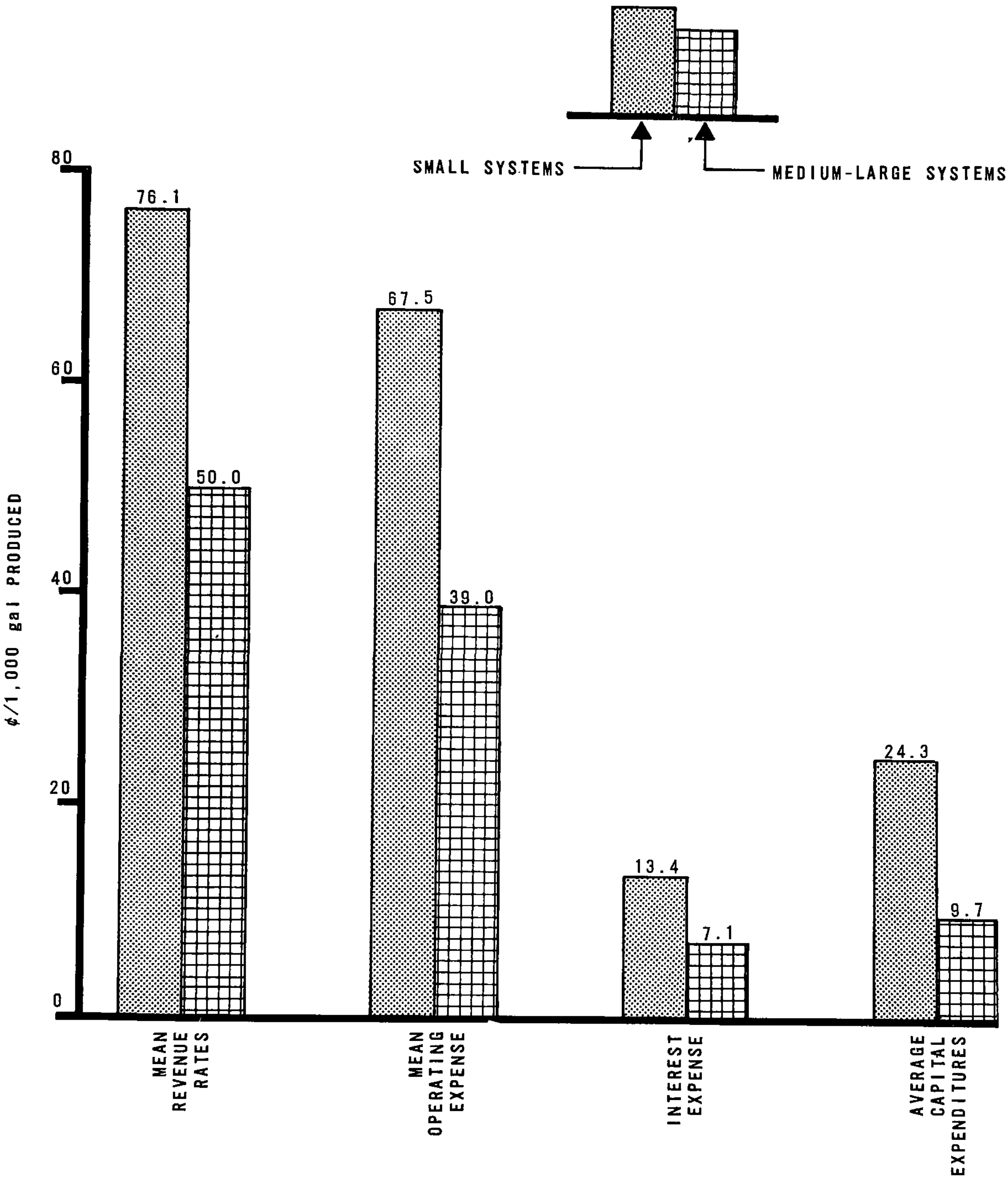


Figure 11.3 COMPARISON OF TYPICAL FINANCIAL CHARACTERISTICS FOR COMMUNITY WATER SUPPLY SYSTEMS

Source: Temple, Barker and Sloane (1977)

Capital expenditures can be financed either by long-term indebtedness (e.g., bonds or loans) or directly out of operating revenues. Interest expense, an indicator of long-term indebtedness, is also significantly greater for small systems. Finally, revenue rates, which include the cost of either direct financing of improvements or indebtedness, average about 50 percent higher for small systems serving under 10,000 people. The revenue differences generally become more pronounced for small systems serving, for example, less than 1,000 people.

Establishing adequate rates to cover financing costs is one problem for small systems, particularly in view of the high rates already charged. Another critical problem is simply obtaining the initial source of long-term capital. Bond sales are one source but may be limited or more costly for small systems. Federal loan and grant sources are available for publicly owned systems, but privately owned systems must rely almost exclusively on commercial sources for external financing.

b. Increased Operating Expenditures

An increase in operating expenditures, either alone or in conjunction with capital improvement, may be necessary to effect improvement. Examples are upgrading treatment, such as increasing chlorine dosage, or increasing operating manpower. The difficulties in increasing operating expenses are similar to those described for capital financing. Mean operating expenses are more than 50 percent greater on a per gallon basis for small systems and are the largest share of total system expenses, as shown in Figure 11.3. Increased operating expenses must be funded totally out of revenues and, therefore, ultimately require rate increases.

c. Source Protection or New Source Development

Source protection measures are one possible solution for improving raw water quality. Small water supply systems depend heavily on groundwater (some of the problem areas relative to groundwater contamination were discussed in the previous chapter). Many of the potential methods for protecting groundwater are either not fully implemented at present or are beyond the technical and legal capabilities of small systems.

If natural raw water quality is poor, e.g., not meeting one or more of the inorganic chemical MCLs, or if available source protection measures are not adequate, another option is to develop a new source of supply. This would also apply to the case of an existing source with inadequate safe yield to meet system demands. The range of this option may be severely limited for many small systems because of the major costs generally associated with new source development. Major water import projects can be developed for the Southern California area, for example, at a lower cost to the consumer than importing higher quality water to any of the 500 small and medium water systems in Texas with excessive fluoride in groundwater (Bernard Johnson, Inc., 1977). In addition, new source development may entail acquisition of water rights. Small systems may be at a particular disadvantage in terms of financial and legal capabilities.

d. Improved Operation and Maintenance Capabilities

In many cases, improved operation and maintenance capabilities rather than major capital improvements may substantially improve the performance of small systems. As shown in Table XI-5, about 20 percent of the small systems that have disinfection facilities still have problems meeting the microbiological standards, indicating a need for improved performance rather than new treatment capability.

One option is to expand manpower or improve skill levels through staffing or salary increases or both. The difficulties small systems face in significantly increasing expenditures have already been mentioned. Another, less costly, option is to obtain training for the available personnel. A number of factors affect the ability of small systems to obtain training for their personnel and of organizations to deliver programs to the small systems. The large number, geographic distribution, and frequently remote location of small systems hamper efforts to deliver formal training programs. Systems with part-time or volunteer staffing and very limited budgets may provide little incentive for individual training. One individual may wear many "hats" -- not only in water system operation and maintenance, but wastewater or other public works responsibilities. Training in this case must be broad in scope but perhaps limited in depth. Turnover may be high and competent workers may be lost to larger utilities.

e. Regionalization/Consolidation

Various concepts for regionalizing, consolidating, or sharing functions have been used or proposed in an effort to reduce operating costs of individual water systems (EPA, 1979). This option is most feasible and attractive for small systems. The possibilities encompassed by this basic concept are wide-ranging and, thus, there are no widely accepted definitions. The term regionalization in this report will refer to the merging of ownership, administrative, and operation functions and, when desirable, of physical facilities, between two or more water supply systems. An example would be the formation of a county water district to assume the functions of many smaller utilities. Consolidation will refer to the sharing of functions or services without necessarily transfer or merging of ownership. An example would be sharing of operation and maintenance manpower. Variations of the latter include concepts such as a "circuit rider," and equipment manufacturer or consulting organization service contracts (EPA, 1979). Another approach is to have investor-owned groups owning and operating multiple systems.

Although all of these concepts may offer some advantages, there has not, historically, been a large-scale move toward regionalization or consolidation. Several factors have tended to restrict such a move. One survey found that a major barrier is political autonomy and an unwillingness by a small utility to release traditional independent control (ASCE, 1977). Regionalization can frequently mean that small utilities merge into a larger utility or district. In this case, a problem may be unwillingness on the part of the larger utility to assume what may be a physically substandard system (unless it is upgraded) and a lack of funds to upgrade or a fear of "bigness" on the part of the small system or both. A third major factor is the lack of authority or incentive for any one agency to assess the opportunities and merits of regionalization/consolidation concepts in a given situation.

f. Identification and Evaluation of Options

Subsections a through e have examined specific solutions to system deficiencies. This subsection looks at how a water system evaluates and selects from those options. In many cases, various potential solutions may exist: new source development, additional treatment (with several variations), improved operational capability, regionalization, or even more extreme solutions such as bottled water or point-of-use treatment (EPA, 1979). To select the most feasible solution, technical, economic and other factors should be evaluated. Then, if the solution requires physical improvements or legal arrangements as in the case of regionalization, a wide range of activities may be necessary such as engineering, approvals, permits, legal processes, and contracting.

In planning, evaluation, and implementation, small systems are often at a distinct disadvantage. Larger utilities will generally have some in-house capabilities or the budget to contract out for engineering services. Small water systems can also employ consulting services, but budgetary constraints frequently limit this approach.

E. Current Sources of Assistance

1. Financial Assistance

External financial assistance for capital improvements, such as loans or grants, is available through some Federal and state agencies. (The basic programs are described in Chapter VI.) Federal programs of particular interest to small water supply systems include those under FmHA, HUD, EDA, and SCS, with FmHA historically providing the greatest source of funding aimed exclusively at small communities. In addition to actual construction costs, FmHA loans and grants can cover miscellaneous engineering, legal and financing costs, purchase of existing systems, and initial operation and maintenance expenses. All of these sources are available only to publicly owned systems or communities.

The only potential, though seldom used, source of assistance for privately owned small systems is loans through the SBA.

Until recently, funding, approval, and review procedures through the various Federal agencies were fragmented and sometimes overlapping. As a result of the Rural Development Initiatives (White House, 1978), several agreements have been completed between a number of agencies including EPA, FmHA, HUD, EPA, DOL, CEQ, and CSA. As these agreements are implemented, beginning in 1979, it is expected that the process for seeking and securing Federal funding sources for rural water and sewer facilities will be simplified and expedited.

Of the existing State loan and grant programs (see Chapter VI, Table VI-3) 5 out of 17 are specifically tailored to small systems. It can be assumed that many of the others use financial situation as a priority criterion and, therefore, would also provide help to small systems. Unlike Federal programs, some state financial assistance programs are not limited to publicly owned systems. Some states, such as Pennsylvania and Washington, provide assistance for planning as well as engineering and construction.

Methods of financing for water systems to comply with the primary drinking water regulations are a prime subject of a report being prepared by the EPA under Section 1442(a)(3)(B) of the Safe Drinking Water Act. This section requires that separate cost and financing consideration be given to small water supply system. Further comment on the adequacy of current financial assistance is deferred to the findings of that report.

2. Technical/Administrative Assistance

In addition to capital improvements, many other problems or needs were suggested in Section D in the areas of management, administrative, and operational capabilities. Some of the existing or planned assistance sources for these functions are briefly described in this section. Several Federally sponsored programs or information sources applicable to small water supply systems are listed in Table XI-7.

Table XI-7

FEDERALLY SPONSORED SOURCES OF
TECHNICAL OR ADMINISTRATIVE ASSISTANCE FOR
SMALL WATER SUPPLY SYSTEMS

Item	Implementing/ sponsoring agency	Status
National Rural Water Association Training and Technical Assistance Program	NRWA/EPA	Operating in 23 states as of 3/79. Funded through 1979.
State-of-Art of Small Water Treatment Systems (Technical Publication)	EPA	Published August 1977.
Manual for Small Water Supply Systems Serving the Public	CSSE/EPA	Published July 1978.
SDWA Workshop and Seminar Materials	AWWA/EPA	Produced 1978.
Handbook for Non-Community Suppliers	AWWA/EPA	Anticipated completion 1979.
Course on Sanitary Surveys for Small Systems	CSSE/EPA	In preparation.

The most comprehensive program is the National Rural Water Association (NRWA) Program. A brief description prepared by NRWA follows:

> Through EPA grants to the National Rural Water Association, member state rural associations are funded to design and operate a grassroots training and technical assistance program which will reach small rural water systems operators, boardmembers and managers through a series of one-day workshops held throughout each participating state. The emphasis is on coordinating the efforts of the state FmHA staff, the state safe drinking water agencies, the regional EPA drinking water program staff, elected officials, and private contractors to work through the workshops. In conjunction with these workshops, a technical assistance network is developed using these same groups and coordinated by the state rural water association program manager/trainer.

The program has been operating since 1977 and has congressional funding through 1979. As of March 1979, 23 state associations, listed in Table XI-8, were active and participating.

Table XI-8

STATES PARTICIPATING IN NRWA PROGRAM
BY EPA REGION

EPA region	States	EPA region	States
I	None	VI	Oklahoma, Texas, Arkansas, Louisiana, New Mexico
II	New York	VII	Iowa, Kansas, Missouri, Nebraska
III	None	VIII	North Dakota, South Dakota
IV	North Carolina, South Carolina, Alabama, Mississippi, Tennessee, Kentucky, Georgia	IX	None
V	Indiana, Minnesota, Illinois	X	Oregon

It is estimated that the state associations have about 5,000 active member water systems and, additionally, many very small systems that are not members are also reached through the program (NRWA, 1979).

The second and third items in Table XI-7 are available publications. The State-of-Art is a fairly technical document on treatment methods and costs, while the manual gives relatively comprehensive coverage of planning, design, operation, maintenance, and administrative suggestions for very small systems. The American Water Works Association (AWWA) offers an extensive package of training, seminar, and workshop materials explaining the requirements and implications of the Safe Drinking Water Act. One item is a self-study training course that is designed especially for small systems in lieu of formal classroom training. The handbook for noncommunity suppliers will serve a similar function but will be much briefer and more simplified. The Conference of State and Sanitary Engineers (CSSE) course will be aimed at training state or local health personnel to better monitor and assist small systems through effective sanitary services. While all of this material is or will be available soon, distribution to all small systems is not automatic. Funds must be available for states to purchase and distribute the material or for the individual system to purchase it directly.

3. Operation and Maintenance Training and Certification

Although this chapter focuses on water supply, training and certification is equally important in wastewater management. Coordination between the two fields in training and certification is not only possible but already closely linked in many states. Much of the following discussion can apply equally to water or wastewater operator training in small communities.

The primary responsibility for training of personnel is generally assumed by each state. The methods of training and the source of materials vary widely from state to state, as evidenced from a survey conducted by the CSEE in 1977 and 1978 (unpublished). Of the approximately 30 states responding in detail to the survey, approximately one-half reported the use of one or more of the following delivery methods: self-study, correspondence, or field training. Such methods, particularly field training, may be more effective in reaching some of the personnel in small utilities than formal classroom training. The survey does not indicate, however, to what extent such training actually reaches the personnel in small systems. Onsite informal training and advice is also to be accomplished as part of routine or follow-up sanitary surveys and inspections. For example, New Mexico reported a dramatic drop in microbiological violations over the first full year of required monitoring under IPDWR and attributed much of this to vigorous follow-up in the form of site visits and advice (Garcia, 1979). Other states have probably experienced similar results.

Other organizations help to train or develop technical materials. AWWA has a number of publications available and conducts training courses through state sections. Some materials, such as the items previously mentioned under technical assistance, are tailored toward small water systems, and contain practical operating advice. In general, however, AWWA does not reach or represent the small utilities to any great extent. Operation training and advice is a significant part of the NRWA technical assistance program, as previously mentioned. The Association of Boards of Certification (ABC), while not directly conducting training, has as one of its primary functions to help states develop an effective combination of training and certification programs through information exchange, development of model training organization, and model certification programs. The ABC recognized in 1974 that "training is not available to operators in remote areas, and many times is poorly located to serve most of those who should be participating" (ABC, 1976).

One program originating from the Rural Development Initiatives (White House, 1978) is an interagency agreement between the Department of Labor and the EPA to provide job opportunities and training for water and wastewater personnel through the CETA program. The program will operate in at least 12 states during 1979 and 1980. It is intended to provide jobs and training for 1,000 persons and training to an additional 500 currently employed operators. It is estimated that rural areas currently employ 105,000 operators in water and wastewater and that an additional 13,000 to 15,000 job openings will be available nationally in the near future.

Operator certification programs are the exclusive responsibility of the states, and have the objective of certifying a level of proficiency in operating personnel. As of 1975, 38 states required certification of all operators of public or investor-owned water systems serving the public (ABC, 1977). The ABC, sponsored in part by grants from the EPA, is very active in developing, testing, and working with states to implement uniform certification programs and promoting reciprocity between states. The certification program's classification systems recognize various levels of responsibility and utility size. Certification programs are certainly an important mechanism to improve and regulate the capability of operating personnel. However, to be effective, training programs must be an integral part of certification and, in turn, the training must be adequate to reach the small system operators.

4. Regionalization/Consolidation Assistance

Although there are no programs or even the authority to actively implement regionalization or consolidation plans at the Federal or state level, a number of mechanisms do exist to encourage this option. The FmHA loan and grant program specifically gives priority to projects that involve merging of ownership, if this results in more efficient and economical service. Many states have statutory authority or policies to encourage regionalization and district formation. The most complete coverage of this subject is contained in an ASCE survey of state agencies (ASCE, 1977). Thirty-four of the fifty states and territories responding reported a written or unwritten policy encouraging regionalization, and 36 respondents indicated planning or district enabling legislation. However, in 29 of these states, the implementation is strictly voluntary, while only 4 states can achieve district formation through planning regulation and only three states have mandatory enforcement powers. A number of regional-type water supply entities (as defined in the survey) do exist, as shown in Figure 11.4.

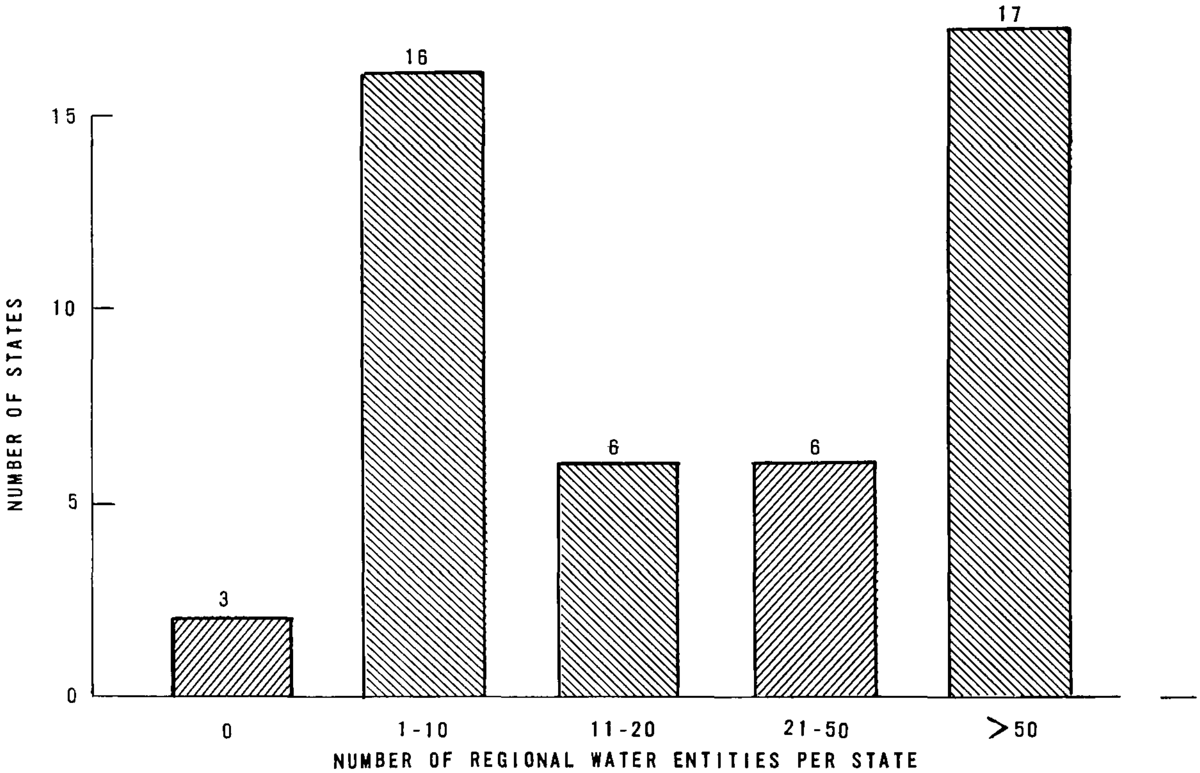
F. Major Findings

The following findings summarize the status of small water supply systems, particularly in terms of their special problems in satisfying requirements under the Safe Drinking Water Act. Potential changes are discussed in Part 3 (Chapter XII).

- Approximately 57 million people, or about one-fourth of the Nation's population obtains drinking water from either small public or rural water supplies. On a peak-day basis, such systems may serve about one-third of the population.

- Rural supplies, which serve about 23 million people (10 percent of the population) are being assessed by the Rural Water Survey in response to the Safe Drinking Water Act.

- Small public water systems constitute about 98.6 percent of all public water systems regulated under the Safe Drinking Water Act and the Interim Primary Drinking Water Regulations (IPDWR). They include:



SOURCE: ASCE, 1977

Figure 11.4 OCCURRENCE OF REGIONAL-TYPE WATER SUPPLY ENTITIES

- Approximately 58,000 small (under 10,000 people), community (year round) water supply systems which are about 95 percent of all community systems.

- Approximately 160,000 noncommunity (seasonal) systems such as in parks or other recreation areas.

. The most prevalent documented quality problem for small community water supply systems is in meeting microbiological maximum contaminant levels; approximately one-fourth of the systems violated this standard in 1978. Furthermore, small systems appear to have a significantly greater problem than larger systems in meeting monitoring and reporting requirements; over one-third of the small systems violated the bacterial monitoring and reporting requirements in 1978.

. Small community systems utilizing surface water sources also experience significantly more violations of turbidity and inorganic chemical regulations than larger systems do, especially in terms of monitoring and reporting.

. Violations data for noncommunity, public systems (e.g. parks) in response to the Safe Drinking Water Act and IPDWR are not yet available.

. There are virtually no data on the quantity problems experienced by small systems. Since 84 percent of small systems utilize groundwater as their source, it can be safely assumed that many small systems experience periodic problems as water tables decline because of drought or as part of a regional decline resulting from mining of groundwater.

. Solid data on the capital structure of small water systems are also limited. Most systems are very small (i.e. less than 1,000 customers) and the investment covers a pipe distribution system, a well or other source, pumps if required and sometimes distribution reservoirs (water tanks). The general inability to raise new capital tends to restrain small systems from all but the most urgent capital improvements for correcting either quantity or quality deficiencies. The adequacy of available sources of capital funding for small systems will be evaluated in the report to Congress under Section 1442 (a)(3)(b) of the Safe Drinking Water Act.

- Small systems typically have a very small staff for operation and maintenance. For many systems the operating staff consists of a single person, often on a part-time or as needed basis. While some system deficiencies might be corrected through improved operation and maintenance, this is not likely to occur without more staff.

- Only a relatively small fraction of the operators of small water systems have had formal training for their task. Typically, the engineer who designs the original system provides both oral and written instructions to those initially in charge of the system. Over time these are handed down to replacement personnel and are commonly progressively reduced to "do this" instructions with little or no "why". Training and technical assistance programs are available, although they tend to reach primarily the larger systems; adequate and appropriate methods of delivery of training are often not available for small systems.

- The lack of training manpower means that small systems often are not aware of deficiencies until serious and obvious problems develop. Training programs should include instruction on how to recognize problems. Once recognized, the operator can seek advice on its correction.

- The present lack and probable permanent impracticality of small systems having significant management- and planning skills or manpower makes it difficult for these systems to be aware of, and evaluate alternative solutions for correcting system deficiencies. Available technical and management assistance programs are not adequate to reach many of the small systems.

- Benefits often can be shown for various concepts of regionalization, consolidation or sharing of functions, and methods exist to encourage such activities. Actual planning and implementation, however, is restricted by local political resistance motivated by the desire to maintain local autonomy, lack of obvious incentive or capability to pursue joint programs, and lack of state authority to motivate it. It must also be recognized that, in some areas, regionalization or consolidation may be impracticable because of physical and cost reasons. There is currently too little information on which to base a preliminary judgement on the applicability of regionalization or consolidation in particular situations.

- The ability of states to regulate and assist small water supply systems is extremely limited by the very large number of these systems and the restricted resources of regulatory and assistance programs. The usual result is for priority to be placed on medium and large systems and for small systems to be largely neglected.

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Part 3: SYNTHESIS OF RECOMMENDATIONS

Chapter XII

FORMULATION OF PRIORITY ACTIONS AND SYNTHESIS OF RECOMMENDATIONS

A. Introduction

Findings of the assessment and public participation phase are reported in Part 1 and of the priority issue analyses in Part 2. This Part 3 describes the context within which major findings and associated options for action are screened, and priority actions are formulated. The intent is to describe the process followed in developing actionable items, and to provide a reference point between this study and Administration priorities, other Federal activities, ongoing or recently completed EPA-sponsored studies and activities, and results of public participation. Subsequently major findings of the study are discussed and related to actions considered by EPA to be feasible, within the context of the existing institutional/legal framework, and sensitive to findings from the public workshops. These actions are then synthesized into generic types of recommendations that can be taken to address two or more problem areas identified as warranting priority. Recommendations synthesized in this Chapter are further consolidated in the Executive Summary, Chapter I.

B. Context for Formulation of Actionable Items

Within a subject area as broad as national water resources -- quantity and quality -- it was anticipated that the investigation would result in many findings each of which could be addressed by any number of options. To narrow the range of findings, and avoid ending up with an unwieldy number of option sets, was a concern. This was handled in two ways: (1) a number of key considerations were established to screen through findings and select those of priority, and (2) options developed in response to these priority findings were first screened by the Task

Force, then reformulated and revised, subsequently screened a second time by EPA executives, and finally crystallized into actionable items discussed herein.

Key considerations which guided the initial screening of findings, and ultimately the formulation of priority actions, are based on explicit recognition of the existing institutional and legal framework (including recent changes in EPA programs and continuing or pending activities within the Federal government) and on public participation results.

1. Institutional and Legal Framework

The basic foundation for this study is clearly provided by the enabling legislation -- §516(e) and 1442(c) -- which focuses on public water supplies and coordination of municipal water supply and wastewater treatment plans. Building upon this foundation, the following factors provided a framework with in which priority actions were formulated.

Hierarchy of Responsibilities. Although the institutional arrangements for water supply and water quality are fragmented, they are well established. Since this is a national report, developed by EPA for Federal action, it is considered important to develop options which are within the purview of the Federal government and scope of EPA authority to adopt.

Administration Priorities. The President's Water Policy Initiatives of July 6, 1978 resulted in several activities which could affect major findings that surfaced in the technical analyses and/or public participation phases of this study. Actions addressing such findings are considered to be preemptive of Congressional or Executive Branch initiatives, specifically:

- The need for Federal aid to states in the form of grants, loans and/or technical assistance for improved comprehensive water management and water conservation programs was established by public workshop results: these topics are being addressed by the Initiatives and are not considered further herein.
- Although far from unanimous, workshop results indicate a public concern for Federal assistance to rehabilitate

aging urban systems. The Institute of Water Resources, Corps of Engineers, is initiating a comprehensive study of needs of urban water supply systems and the role of the Federal government in providing assistance and thus recommendations are deferred to that study.

- A Groundwater Interagency Task Force is in the process of developing final recommendations for implementing National Water Policy as it related to groundwater; thus action formulation herein focuses on improvements in existing EPA programs.

U.S. Water Resources Council Level B (§209) Program. Public support for this program was registered in the workshops; analysis results indicate that it could provide a vehicle for coordinating water supply and water quality planning; and, it is being reviewed by WRC in response to OMB request and revisions/modifications are anticipated. EPA supports this effort as well as proposed expansion of WRC's Title III Program but recognizes that a decision to provide funding for Level B studies and/or the Title III Program will be made by Congress. Thus an action calling for use of the Level B Program as a vehicle for coordination is not further considered.

Current EPA-Sponsored Studies. Other issues resulting from the assessment and raised in the workshops include:

- Cost of complying with primary drinking water regulations.

- Difficulties -- cost and other -- encountered by small systems in providing adequate and dependable supplies of safe drinking water.

- Interrelationship between water allocation decisions and water quality programs.

Cost of compliance and financial difficulties encountered by small systems in complying are being studied in response to §1442(a)(3)(B) of the Safe Drinking Water Act. The third above-referenced issue has recently been addressed by a study in response to §102(d) of the Clean Water Act. This study defers action formulation to those detailed studies and incorporates by reference recommendations developed therein.

Revision of EPA Regulations. Regulations for trihalomethanes and synthetic organic chemicals in public water supplies, and grant eligibility of multiple purpose projects are controversial public issues. They are both being addressed by EPA in separate activities; thus these issues are not addressed in the action formulation phase.

2. Public Workshop Results

Public workshop results indicate a strong preference for taking advantage of coordination opportunities that exist in current Federal programs and an aversion to increasing the complexity of the Construction Grants (§201) funding process by adding new requirements for funding eligibility (see Chapter VII). Also expressed was a desire to adopt a wait-and-see approach regarding existing legislation and programs before embarking on new laws and programs. These concerns as well as national concern over inflation and energy are pragmatic considerations in developing realistic actionable items.

It is also recognized that Congress devoted considerable time to amending the Safe Drinking Water Act and Clean Water Act in 1977 -- an observation that runs parallel to public concern that programs and regulations responding to the amendments should be allowed to stand the test of time. EPA acknowledges the legitimacy of public concerns and the fact that extensive reexamination of programs and regulations presently being implemented and of the enabling legislation is premature. This recognition provided a further caveat for action formulation.

C. Formulation of Priority Actions

As mentioned earlier, priority actions were formulated and agreed upon during several iterations between the contractor and EPA executives as well as Task Force members. These respond to major findings documented in Parts 1 and 2 which were screened according to key considerations discussed above. The resulting actionable items are discussed in the following subsections.

1. Coordination Opportunities in EPA Programs

Water quantity and water quality are typically planned under distinct and separate legislative mandates to serve different purposes and without regard to their possible interrelationships. To bridge the gap between quantity and quality planning has been an issue for many years. Increased recognition of interrelationships, and the explicit mandate of §516(e) has rekindled interest.

This study found that in as much as opportunities for better coordination exist, in reality coordination rarely takes place. When it does, it is generally because quantity-quality planning is under the aegis of a single agency or because the need for coordination has been identified and pursued at the local level. Similarly, there are opportunities for better coordination within EPA's Construction Grants Program and the Agency's new Water Quality Management (WQM) Program (an offshoot and consolidation of earlier programs responding to §208, 106 and 303(e) of the Clean Water Act).

Based on these findings and others as documented in Chapter VIII, priority actions are:

(1) Make use of the Construction Grants process (i.e. specifically the Step 1 wastewater facility planning guidance) to emphasize early identification of coordination opportunities and more comprehensive consideration of interactions between wastewater treatment alternatives and public water supplies.

(2) Utilize the new WQM Program to identify more opportunities for coordinating planning of public water supply and wastewater treatment systems.

(3) Issue guidance to expedite identification and implementation of coordination opportunities with due regard for local, state and regional differences.

The existing Step 1 planning guidance does contain several milestones where need for or advantage of coordination can be identified (see Chapter VIII). The guidance can be supplemented with additional direction which emphasizes data such as: existing quality and quantity of water sources serving the wastewater planning area; per capita use of water vis a vis capacity of facilities; surface and groundwater sources serving other areas but potentially affected by any wastewater treatment alternative, including the "no project" alternative; ongoing water supply planning in or around the wastewater planning area; and, consolidation of data on interrelationships during the initial planning stages. By so supplementing the existing guidance it will be possible to further assure that a local need/opportunity to coordinate is identified (when such an opportunity exists) without making coordination an across-the-board requirement for grant eligibility, further complicating Step 1 planning, and possibly slowing municipal progress in meeting national water quality goals.

Regarding EPA's Water Quality Management program, the existing scope can be expanded beyond its present emphasis on water quality so as to assure that: interactions with water supply are identified; the need or opportunity to coordinate is assessed; and, institutional arrangements are established. If such an expanded scope is to be realizable and effective over the long term it will be necessary to provide stable funding for developing and updating WQM plans, and for effectuating EPA-State Agreements to assure conformance to such plans and continuing progress in their implementation.

All of the above actions are within the scope of EPA's present authority and none would entail a concerted effort to revise existing regulations, amend current legislation, or implement a new and unfamiliar program. Each would contribute to further coordination of municipal quantity-quality planning within EPA's programs. Although new funding authorizations may not be required, stabilized appropriations are important if the program is to achieve its full potential. Based on these observations and the findings of this study, these actions are feasible and implementable.

2. Opportunities for Municipal Conservation

The conservation ethic (i.e. demand management) has been receiving increased recognition as a desirable alternative to increased shortages or alternatively, increased structural solutions to such shortages, inflated prices, and environmental degradation. The lack of consensus on how to conserve and who should do the conserving can be inferred from the ongoing debate on National and State Water Policy. This failure to manage demand has been a factor in some situations for causing undesirable conditions such as groundwater mining, inadequate streamflow for in-stream uses, increased competition for available sources, and increased expenditures for water supply and municipal wastewater treatment.

This study focuses on municipal water conservation and finds that it is often disregarded because it is a relatively small use in the overall picture, municipal shortages are by no means universal, and it is feared that water rate increases would outweigh savings from reduced water use. Following an approach which looks at synergistic effects of water conservation, the study finds flaws in the conventional wisdom. Specifically, analysis results of a moderate (i.e. no change in life style) and widespread municipal conservation program, as documented in Chapter IX, point to: a potential Three percent reduction of energy imports and corresponding reduction in balance-of-trade deficit (as a result of energy savings in hot water heating and in water supply and wastewater systems); a potential savings of $150 million annually in wastewater facilities construction grants or, alternatively, a speed-up in the timetable for municipal compliance with Clean Water Act goals; and, a favorable benefit-cost ratio associated with municipal conservation even in a no-growth, water-rich community.

Despite these favorable portents for municipal conservation this study learned that available information is neither readily accessible nor sufficiently clear and comprehensive to enable municipalities to weigh the advantages and disadvantages of conservation, and to devise a strategy suited to local characteristics. This observation is supported by public workshop data as is the desirability for technical assistance and leadership from the Federal level.

In examining EPA programs it is found that increasing the emphasis on water conservation in the new WQM program can make it an attractive vehicle for improving water quality as well as for achieving savings in water, energy, and money. Further this investigation of EPA programs discovered that although Construction Grants does require a municipality to develop a water conservation and/or wastewater flow reduction program under certain circumstances, it does not explicitly reward a community having low per capita flows nor penalize a grant recipient when the reverse is true.

Based on these findings and other supporting data provided in Chapter IX, the following are considered to be actionable items:

(1) Redirect or improve Federal data gathering efforts related to water supply and water quality so as to improve the data base on advantages and disadvantages of municipal conservation under different assumptions reflecting local characteristics.

(2) Synthesize municipal conservation data in a form amenable to the needs of State and local decision makers.

(3) Devise a mechanism for consolidating and transferring information (e.g. on conservation technologies and techniques, costs, benefits) to states, among Federal agencies, and to national organizations.

(4) Use the WQM Program to address interrelationships between municipal conservation and water quality.

(5) Create an explicit mechanism for providing financial incentives to conservation-minded communities through Construction Grants as well as disincentives for excessive per capita wastewater flows, and for encouraging more widespread adoption of municipal conservation strategies and technologies.

Federal data gathering on water use and public water supplies has intensified as exemplified by references made throughout this report to recent or ongoing studies and Federally-sponsored research efforts. To effectuate actions one through three, these efforts will need to be: directed to provide information on significant location-specific parameters of municipal conservation; coordinated so as to assure consistency in data (e.g. similar units of measurement and definitions, consistent assumptions); analyzed and synthesized with an eye toward the intended user-audience for such data; and, made available in the form of technical assistance to decision makers in the public and private sectors.

Implementation of actions one through three would require presidential action in the form of appointing a lead Federal agency for carrying out basic data gathering, research, and technical assistance activities. Such action would supplement the aforementioned Presidential Water Policy Initiatives (i.e. to provide $25 million annually for technical assistance to States) and strengthen implementation of a national water conservation strategy. A modest appropriation of funds would need to be made by Congress.

Supplemental guidance could be added to new revised regulations for the WQM Program and a WQM plan could be required to include a water conservation element in order to implement action four. Emphasis would be on analyzing the quantitative impacts of conservation (e.g., reduced water pollution control costs or decreased pollutant discharges) as well as those less amenable to quantitative analysis (e.g. improved in-stream quality, reduced risk of overdeveloping surface water sources or depleting groundwater, or increased streamflow during low flows). Implementation of this action is within the scope of EPA's present authority.

Regarding provision of incentives for conservation through Construction Grants, public participation results indicate a perception that Federal programs generally neglect to reward communities with well maintained water and/or wastewater systems (i.e. an effective if indirect conservation mechanism) and/or with water conservation programs. Adoption of action five would help to dispel this notion and could provide momentum to municipal conservation, in particular in communities with identified needs for wastewater facilities and hence eligible for funding. Specific actions seen to be particularly useful include providing a bonus/penalty system to discourage excessive per capita wastewater flows, and making water conservation technology eligible for funding. Implementation of action five would require Congress to authorize a bonus/penalty system, and to amend the Clean Water Act so as to provide funding for conservation technology through EPA's Construction Grants Program.

In combination adoption of all of the above actions would be a significant force in moving municipal conservation across the threshhold without making major legislative changes, creating new Federal programs, and/or increasing national costs for pollution control. They are all feasible within the existing institutional/legal framework desirable from a national viewpoint, and of priority.

3. Opportunities for Municipal Reuse

Direct reuse currently accounts for about three percent of municipal effluents in the U.S. and its future potential is thought to be significant (see Chapter IX). It has received considerable support from the Federal government, in particular through "innovative and alternative" provisions of the Clean Water Act as these relate to bonuses available through Construction Grants.

Municipal effluent can be a dependable source of relatively high quality water. This study found that the location of facilities near urban areas is particularly attractive for steam electric and industrial uses, and that as a water treatment strategy reuse alternatives have significant appeal in water-short and coastal areas. Although use of municipal effluents for potable purposes is not considered, reuse can provide a mechanism for obtaining potable supplies from another use by exchanging/substituting treated effluent. Reuse can also be beneficial if it allows for increased streamflow and/or reduced discharges and hence improved in-stream quality. These less tangible benefits can be lost, however, if the in-stream water "saved" is appropriated by another use.

Despite these advantages, and the availability of information on use and effectiveness of various treatment techniques, this investigation uncovered several serious impediments to widespread implementation. Foremost is cost of reuse relative to the cost of other sources of supply and/or alternatives to additional supply, as well as cost and high energy use of the technology itself. Such costs result from location-specific characteristics for which there are significant gaps in existing data.

A second leading and more global constraint is uncertainty over risks to human health from using treated wastewater for nonpotable purposes. Associated with this constraint is lack of scientific consensus on degree of treatment needed to protect against such risks. Finally there is the question of psychological acceptance of reuse, an issue with no easy or obvious answers. EPA and the Office of Water Research and Technology (OWRT), U.S. Department of Interior, sponsor basic research and development projects which will shed light on present uncertainties about reuse of municipal effluents.

There are provisions within EPA's §201 program to encourage reuse projects in response to Congressional intent in the Clean Water Act amendments, and the aforementioned Multiple Purpose Funding Guidelines study will clarify which types of reuse components of a wastewater treatment alternative are eligible for funding. This study found that most reuse projects have been implemented as a result of local recognition and local need, and thus that a mechanism for identifying an opportunity prior to Step 1 funding could provide a further boost to reuse and recycling of nutrients.

Based on these findings and others as documented in Chapter IX, actionable items are:

(1) Utilize the WQM Program to provide a mechanism for identifying reuse opportunities and establishing institutional arrangements prior to Step 1 facilities planning.

(2) Require assurance from grant recipients that any improvement of water quality which results from a grant funded project featuring reuse will be maintained.

(3) Improve and consolidate the data base, thereby enhancing the analytical basis for decision making, on the health effects of reuse for nonpotable purposes.

(4) Illustrate, through demonstration cases, the advantages and disadvantages of reuse under various circumstances.

(5) Analyze and display the impacts of alternative reuse scenarios, in particular economic effects and impacts on water quality.

(6) Provide technical information on control measures for mitigating or minimizing groundwater contamination from reuse technologies.

The first action could be implemented by requiring a WQM plan to identify reuse and recycling opportunities and to address the relationship between such opportunities and water quality. Action two could be adopted by the Administrator and implemented through EPA-State Agreements. Options three through six would require continuation and improvement of current EPA-OWRT research activities, and EPA's present technology transfer programs.

All actions are within EPA's present mission, and none would require a significant shift in funds or program emphasis. In combination they would augment other EPA efforts (e.g. bonus §201 funds for innovative and alternative technologies such as reuse and recycling) and clear up some of the foremost uncertainties which stand in the way of wider implementation of reuse technology. Thus they are all judged to be feasible, in the national interest, and of priority.

4. Opportunities to Improve Groundwater Management

Groundwater (quantity and quality) has been less well understood and less stringently managed and protected than surface water. The importance of protecting groundwater in the U.S. is underscored by the finding (see Chapter X) that about 47 percent of the Nation's population rely on groundwater as a drinking water supply source. Heading the list of potential quantity problems is the finding that 25 percent of annual groundwater pumpage constitutes mining; in addition to quantity problems, mining can cause or at least augment pollution of an aquifer.

Threats to groundwater quality are many and varied including: over 130,000 surface impoundments of polluted water; more than 20,000 landfills and dumps handling over 500 million tons of waste annually; and, over 400,000 injection wells introducing in excess of 900 billion gallons of wastes into the ground annually. In addition there are serious threats from nonpoint sources.

The study also found that while the above-referenced sources of groundwater pollution are being addressed by recent legislation and Federal programs, implementation is still in progress and assessment of effectiveness is premature. In addition, some states regulate groundwater with varying degrees of enforcement, but many do not; such regulation is up to a state to initiate.

At the Federal level, EPA has recently proposed Underground Injection Control regulations in response to the Safe Drinking Water Act; these will address injection wells. The Sole Source Aquifer provision of the same Act provides an additional opportunity to improve groundwater management. EPA's WQM program is yet another vehicle for identifying needs for improved groundwater management, planning accordingly, and implementing plans in a systematic fashion. The WQM program also addresses nonpoint sources of pollution.

Another significant piece of legislation is the Resource Conservation and Recovery Act. Under this Act a surface impoundments inventory and assessment is being conduct; there are provisions for controlling those which contain hazardous wastes. Landfills are also included in proposed regulations under the Act (i.e. regulations which will be consolidated with those of the Underground Injection Control program) and closure of dumps upon completion of a landfill/dump inventory will address these potential sources of groundwater pollution.

Based on the above findings, and others provided in Chapters IV and X, actionable items are:

(1) Progressively implement and monitor current EPA programs designed to improve groundwater management and protection.

(2) Utilize the WQM program to address integrated quantity/quality planning for surface and groundwaters and for their interactions as these relate to water quality.

(3) Require coordination between a WQM plan and a hazardous waste control plan.

(4) Provide technical assistance to the states for implementing provisions of the Resource Conservation and Recovery Act and the Underground Injection Control Program.

Adoption of the first action only requires a renewed commitment from EPA to carrying out Congressional mandates, and the other three actions are within EPA's authority to adopt. While these actions could improve Federal programs for groundwater protection, and are considered to be of priority, it is explicitly noted that the states have considerable authority and responsibility for managing and protecting these sources.

5. Opportunities to Assist Small Water Supply Systems

This study focuses on opportunities to address problems other than financial that small public systems may face and defers the financial analysis task to the aforementioned EPA study in response to §1442(a)(3)(B) of the Safe Drinking Water Act. It is noted for the record, however, that during the initial assessment of issues and investigation of public views it was found that small systems typically experience capital and operating costs that are two to three times greater than for large systems, and that there is considerable public concern over the plight of small systems (see Chapters VI and VII).

This study found that small systems -- i.e., those serving under 10,000 people -- constitute over 98 percent of all public water systems, serve approximately 57 million people on a daily basis, and may serve up to one third the population on a peak day. Preliminary estimates, based on aggregated and incomplete national data, indicate that a significantly higher percent of small community systems violated microbiological maximum contaminant levels and bacterial monitoring and reporting requirements than did large systems. Data are not available on violations by noncommunity systems (e.g. in parks); as there are about 160,000 of these types of small systems the states have difficulty in adequately monitoring and regulating them.

A data search revealed that data on water quantity problems experienced by small systems is extremely limited, although it can be assumed that since the vast majority rely on groundwater many of these systems experience periodic shortages. Similarly there is limited data on the capital structure of small systems. It is found that small systems could benefit from improved operating training materials and increased access to such materials. Similarly it is found that although many Federal and some state agencies provide assistance to small systems, information transfer on available technologies and vehicles for planning and management should be increased.

Based on these and other findings as documented in Chapter XI, actionable items are:

(1) Intensify current Federal actions aimed at developing and improving operator training materials.

(2) Consolidate information existing in various Federal agencies on available technology, and planning and management techniques relevant to small public systems.

(3) Improve delivery methods and/or increase accessibility to small systems of the above educational and informational material.

(4) Provide increased support to states for expanding their surveillance programs.

Adoption of the above actions could be accomplished under existing authorities by interagency agreement. A coordinated thrust by Federal agencies which do provide assistance to small community systems could improve the ability of these systems to identify their problems, develop options for resolution of such problems, and implement a chosen alternative. In turn this would further assure adequate and safe supplies for all of the population. Thus these actions are judged to be feasible, in the national interest, and of priority.

D. Synthesis of Recommendations

Actionable items developed in the previous section are regrouped in this section and synthesized into one of the following generic recommendation categories:

- Those which relate to improvements in EPA's Water Quality Management Program.
- Those which relate to modifications to EPA's Construction Grant Program.
- Those which respond to the conservation thrust of the President's Water Policy Initiatives.
- Those which respond to Presidential Initiatives for Rural Development.
- Those which require state or local initiative.
- Those which enhance achievement of basic mandates in several EPA programs.

The resulting recommendations are further consolidated in the Executive Summary, Chapter I.

1. Strengthening the Water Quality Management Program

A first round of §208 Areawide Wastewater Planning has provided an opportunity for local/state involvement in implementing national water quality goals and a foundation upon which to build an EPA/state/local partnership. The new consolidated WQM program, which as noted features revised and streamlined regulations for combining §208, 106, and 303(e) activities is intended to overcome many weaknesses that were identified in EPA's retrospective evaluation of initial results from the various program activities.

Because the WQM program is comprehensive, is familiar to local/state agencies (and to an extent the public at large through public participation activities), and has been tested and revised, EPA believes that it is the most appropriate planning vehicle for responding to §516(e) and many concerns implicit in 1442(c). In addition the programs now encompassed by the WQM program were responsive to the Clean Water Act thereby enabling the EPA

Administrator to act under existing authorities and to strengthen the WQM program so as to address findings of this study. Specifically the Program should be modified to encompass the following actionable items:

- Address interrelationships between municipal water conservation and water quality.
- Address interrelationships between recycling and reuse, and water quality.
- Investigate opportunities to integrate quality/ quantity planning for surface and groundwaters as well as their interactions related to water quality.
- Address coordination of public water supply and wastewater management plans.
- Address coordination of water quality management and hazardous waste disposal plans.

Requirements to incorporate the above in a State or Designated Area WQM Plan would help to bridge the gap between water quantity and water quality plans, motivate establishment of working relationships between diverse agencies, provide additional opportunities to identify need or opportunity to coordinate plans, and enhance continued achievement in meeting national in-stream water quality and safe drinking water goals. Implementation of these requirements will require increased and stabilized funding.

2. Modify the Construction Grants Program

EPA's Construction Grants Program provides a unique opportunity to mesh results of WQM planning with an implementation action -- i.e., construction of facilities -- in particular when a need to coordinate facilities plans with water supply has been identified prior to Step 1 planning. Even if such a need has not been identified, or there is no approved WQM plan, the existing Step 1 planning guidance provides opportunities to identify coordination needs and establish cooperative arrangements with water supply agencies. EPA believes that the Construction Grants Program combined with a strengthened WQM Program can produce synergistic results thereby improving the effectiveness of both programs in terms of achieving national goals.

The program also provides a unique opportunity to enhance coordinated planning while simultaneously encouraging municipal water conservation policies. As it now stands, EPA can require a municipality to develop a water conservation and/or wastewater flow reduction program if per capita flows are more than 70 gpd. By strengthening this requirement through specific financial incentives, EPA believes the program will better motivate municipal conservation initiatives.

Based on the above observations, the Construction Grants Program should be modified to encompass the following priority actions:

- Reemphasize the need for early and more complete identification of interactions between wastewater management alternatives and areawide public water supplies and more comprehensive consideration of such interactions.

- Reemphasize the importance of examining the interactions between wastewater management alternatives and groundwater.

- Provide a construction grants bonus of up to 5 percent for communities which can demonstrate a successful water conservation/wastewater flow reduction program and a penalty of up to 5 percent when per capita wastewater flows are excessive.

Adoption of the first two minor modifications (i.e. rewrite of existing planning guidance to focus a grant recipient's attention on water quality-quantity interactions) would increase the probability that coordination opportunities are identified and acted upon early enough in the Step 1 process to influence formulation and evaluation of wastewater treatment alternatives. Implementation will require direction from the EPA Administrator.

Provision of financial incentives for municipal water conservation would enhance achievement of national water quality goals while simultaneously encouraging demand management as a means of assuring adequate and dependable drinking water supplies. Implementation will require Congress to authorize a bonus/penalty system for conservation and wastewater flow reduction.

3. Designate a Federal Lead Agency for Municipal Water Conservation

In response to the water conservation thrust of the Presidential Water Policy Initiatives, the major Federal water resources agencies are examining present programs with an eye toward removing disincentives and providing incentives for municipal water conservation within existing legislative authority. EPA believes that a united and coordinated front is required in order to make a quantum jump from traditional emphasis on supply management to water demand management, and further that to achieve this change from business-as-usual, a Federal lead agency is needed to orchestrate a coordinated national effort. The most significant contribution that this lead agency could make at this time is to synthesize a comprehensive data base with emphasis on providing information oriented toward local decision makers.

Based on the above observations, the President should take action to:

- Designate a lead Federal agency for municipal water conservation.
- Instruct that agency to direct relevant research and data gathering efforts.
- Direct that agency to synthesize practical, concise and clear information on the advantages and disadvantages of municipal water conservation.
- Make such information available to states, other Federal agencies, and relevant national organizations.
- Provide technical assistance to potential user groups at the national and state levels.

In addition to Presidential action, implementation of the above would require Congress to provide appropriations to the designated agency to carry out its responsibility. Successful and widespread adoption of municipal conservation strategies would provide multiple local and national benefits which would greatly exceed the cost of the program.

4. Synthesize and Coordinate Assistance to Small Public Water Supply Systems

Several Federal agencies and some states have programs attuned to the needs of small water supply systems. EPA believes that the effectiveness of these programs could be enhanced severalfold by entering into a Federal-state partnership and intensifying efforts to assist public systems serving 10,000 or less persons. Based on this observation, the EPA Administrator, in cooperation with the appropriate Federal agencies and the states, should take action to:

- Develop and improve operator training material.
- Improve delivery methods to achieve a more widespread distribution of these materials.
- Synthesize and consolidate existing information available from the relevant agencies on planning and management techniques, on available technologies, and opportunities for Federal/state assistance.
- Improve delivery methods to achieve a broader awareness of available assistance by type and to increase the accessibility to Federal financial assistance available to small systems.
- Increase support to states for expansion of surveillance programs.

Adoption of the above (and other actions to be agreed upon once the cooperative venture is underway) could provide a more unified approach for assisting small systems in meeting drinking water quality regulations and delivering adequate quantities of water. Implementation is within EPA's present authority under the Safe Drinking Water Act and responsive to Presidential Initiatives for Rural Development.

5. Encourage State and Local Initiatives

Various issues impeding national progress in more rapid achievement of goals in the Clean Water Act and Safe Drinking Water Act are primarily resolvable at the state and local levels. EPA recognizes this division of responsibility and believes it is important to encourage state and local governments in addressing these issues by highlighting those believed to be significant. Based on the findings of this and other recent studies, EPA encourages state and local initiatives to:

- Revise state water law where needed in light of recent findings and changing national priorities.

- Improve state/local capabilities in comprehensive water resource planning and demand management by participating in WRC's Title III Program, its Level B Program, and Technical Assistance Program on Conservation (as proposed by the Administration).

- Develop programs and regulations to protect groundwater from contamination by injection wells and waste disposal facilities.

- Develop or improve assistance programs for small public water supply systems in concert with complementary Federal programs.

- Develop, with Title III assistance, coordinated framework plans for integrated quantity-quality planning.

6. Improve Ongoing EPA Programs and Activities

Several of the priority actions developed in the previous section require fine tuning or reinforcement of present EPA programs in contrast to changes in program emphasis or scope, changes in legislative mandates, or Presidential action. Actionable items that should be adopted include:

- Continue to work closely with OWRT to improve the scientific data base on health effects of nonpotable reuse, on its practical potential in various settings, and emphasizing advantages and disadvantages particularly as they relate to cost and water quality.

- Obtain guarantees from grant recipients that indirect improvements in water quality resulting from grant funded reuse and recycling projects will be maintained.

- Provide training seminars to the states on implementing the Resource Conservation and Recovery Act and the Underground Injection Control regulations.

- Encourage state water supply agencies to develop, making maximum use of available data, and maintain information on dependable quantity and quality of in-state sources under average and drought conditions.

- Improve delivery of information on technical control measures to minimize groundwater contamination from waste disposal operations and reuse technologies.

TECHNICAL APPENDICES

Appendix A

BASES FOR ESTIMATING MUNICIPAL WATER CONSERVATION POTENTIAL

1. Residential In-House Conservation Potential

Present water use in residences served by municipal water supplies is about 65 gpcd as a national average. The distribution of this amount among various in-house uses is presented in the first two columns of Table A-1 by percentage and by gpcd. Although these numbers are not based on nationwide statistics, the total fits well with data on total domestic water production from WRC's Second Assessment (see Table IX-1) and with the 60 to 75 gpcd range of literature estimates for total in-house use. The indicated distribution of water among in-house uses is drawn from several sources but is based more on the collective judgment of those sources than on strong data. Still, any change in distribution which would result from "perfect" data could not be large.

The third column of Table A-1 indicates a range within which the national average for each in-house use might fall if selected conservation measures were implemented to their full, reasonable potential nationwide. This range is generally about 55 to 75 percent of estimated present use, indicating that there is a potential to save 25 to 45 percent.

The detailed basis for each of these estimates is given in Table A-2. The "improved design" specifications are primarily from the California Department of Water Resources (1976) bulletin on water conservation but are confirmed by other references and are those specifications generally being adopted in municipal conservation programs. These specifications are judged to be conservative; further research and improved fixture design may show that more savings can be easily achieved. For example, there are some indications that a 2.5 or 3 gallon per flush toilet and a 2 or 2.5 gallon per minute showerhead may be adequate and practical (Pennsylvania State University, 1975). This remains to be seen, however.

Table A-1

MUNICIPAL, RESIDENTIAL IN-HOUSE WATER USE
AND CONSERVATION POTENTIAL

(National Averages)

Fixture/Activity	Percent of Present Use	Present use[a] (gpcd)	Potential Range with Conservation[c] (gpcd)
Toilet	40	25	14-17
Bath/Shower	30	20	13-17
Lavatory Sink	5	3	2-2½
Laundry	15	9	3-6
Dishwashing	5	4	2-3
Cooking/Drinking	5	4	2-2½
Totals	100	65[b]	36-48
Precent Reduction	-	-	25-45%

a. Based on Deb (1978); Metcalf & Eddy (1976); Flack *et al*. (1977); and Bailey *et al*. (1969).

b. The range from various references is 60 to 75 gpcd.

c. Summary of Table IX-4.

Table A-2

RESIDENTIAL IN-HOUSE CONSERVATION POTENTIAL

Location/Activity	Improved Design	Water Saved: Percent of Conventional Use	Water Saved: gpcd	Hot Water Energy Saved[e] (10^3 BTU/Capita-Day)
Toilets	3.5 Gal/Flush	30-55	8-11	0
Showers	3 Gal/Min (Max)	25-50	2½-5[a]	1.1-2.2
Kitchen & Lavatory Faucets	1.5 Gal/Min (Max)	10-30	½-1	.2- .4
Pressure Reducing Valve	50 PSI (Max)	15-25 (of in-house use)	3-6[b]	1.1-2.2
Hot Water Pipes	Shorter/Insulated	4-12 (of hot water)	1-2	.8-1.5
Clothes Washer	16-19 Gal/Load	35-65	3-6	1.5-3.0
Dish Washer	7.5 Gal/Load	0-50	½[c]	.4
Education	Avoid Waste	10-25 (of faucet use)	½-1½[b]	.2- .6
Totals			17-29[d]	4.5-8.9[d,c]

a. Low estimate to allow for 50% baths.

b. Low estimate to lessen double counting.

c. Low estimate to allow for households without dishwashers.

d. Assumes pressure reducers applicable to 30% of residences.

e. Assumes 100% energy efficiency, this is a conservative estimate of energy savings.

The estimated percentage of water saved compared with conventional use (third column from the left in Table A-2) also draws heavily on the California DWR bulletin but depends on other sources, as well. Shower savings are an especially important item because of associated hot water energy savings; for this estimate the recent work by Sharpe (1978) is used. This column of estimates is a crucial part of the analysis. There are two main reasons for this:

- Although it is relatively easy to compare the design characteristics of a conventional fixture and a water-saving device, this is not the same as comparing the way the two devices are used. For example, some conventional showerheads have flow capacities greater than 12 gallons per minute. However, replacing these with a 3-gallon per minute showerhead does not mean a 75 percent reduction in water use. Indeed, the conventional showerhead may have been used primarily in the 3 to 5 gallon per minute range; the new showerhead could reduce water use by 25 percent or perhaps even less. Very few data are available on how conventional fixtures are now used and even less is known about how water-conserving fixtures would be used.

  Although the typical range of design characteristics of conventional fixtures and appliances is known, few data are available on the distribution of existing items over that range. For example, although one source states that most showerheads have maximum discharge rates of 5 to 10 gallons per minute, few other references make comparable claims.

Relatively conservative assumptions have been used in translating these percent reductions into national average per capita daily water savings (fourth column from left in Table A-2). This makes allowance for the above difficulties and also takes into account other important considerations (such as the quantity of bathing water used for baths as opposed to showers) as has been indicated in the table's footnotes. Although double counting could have been a problem in summing the water savings, only the pressure reducing valve and education to avoid waste would involve water which also is used in the other categories. Thus very conservative assumptions were adopted for savings from these actions and it is estimated that double counting has been eliminated (although detailed analysis to verify removal of this type of error has not been performed).

The economic feasibility of each of these conservation actions is addressed in Table A-3 both for new construction and remodelling and for retrofitting. Costs of each action are estimated, and water and energy savings are then compared with costs in terms of benefit cost ratios. It is noted that only three actions are shown to be economically infeasible:

- Insulation of hot water pipes as part of a retrofitting program.
- Replacement of clothes washers before they wear out.
- Replacement of dishwashers before they wear out.

2. Residential Outside Conservation Potential

Available information on residential outside use of water and on conservation potential is less reliable than it is for in-house use. However, a working estimate of the national average outside use is 28 gallons per capita per day. This figure is the residual obtained by first estimating and then subtracting the other components from WRC's (1978) total domestic use indicated in Table IX-1 (Chapter IX). It fits well with the data in Table A-4 on outside use for various types of residences which were reported in the late 1960's and is the best available information on present use. It is estimated that 90 percent of outside use is for landscape sprinkling (Calif. DWR, 1976).

Using the above estimate as a starting point and making assumptions on conservation in a manner similar to the preceding section results in Table A-5 which indicates a potential savings of 30 to 50 percent.

The estimated impacts of metering and pressure reduction are from Metcalf and Eddy (1976) and Flack et al. (1977). Sprinkling and landscape estimates are drawn primarily from California DWR (1976).

The economic feasibility of each proposed action is examined in Table A-6. It is interesting that both water meters and pressure reducing valves appear to be justified in new construction but other water

Table A-3

RESIDENTIAL IN-HOUSE CONSERVATION POTENTIAL (ECONOMICS)

	Additional Cost/Fixture		Benfit/Cost Ratio[a]	
Location/Activity	New, Remodel or Routine Replacement	Material (+ Labor)	New, Remodel or Repalce	Retrofit
Toilets	0-6	1-5 (+5)	6.2-∞	3.7-8.5
Showers	0-5	1-5 (+4)	6.6-∞	3.7-13.2
Kitchen & Lavatory Faucets	0-2	0-2 (+2)	2.1-∞	1.0-4.1
Pressure Reducing Value	30	30 (+20)	3.3-6.6[c,d]	2.0-3.9[c,d]
Hot Water Pipes	0-20[b]	50 (+80)	2.0-∞	0.3-0.6
Clothes Washer	20-30	300 (+20)	2.9-8.6	0.3-0.6
Dish Washer	0-10	300 (+10)	2.0-∞	0.1
Education	$2/Residence-Year		0.6-1.8	

a. Assumes 7% interest, 20 year life, energy at 25¢/therm, water at 60¢/1000 gallons, 2 bathrooms/home, and 4 people/home.

b. Insulation at 50¢/foot; counterbalanced by less pipe.

c. Includes outside water savings.

d. Low estimate of water saved to lessen double counting.

Table A-4

OUTSIDE WATER USE FOR VARIOUS TYPES OF RESIDENCES

Type of Residence	Gal/Day Residence	gpcd
Metered Public Water and Public Sewers		
West (10 areas)	186	49.0
East (13 areas)	80	19.5
Metered Public Water and Septic Tanks		
(5 areas in East)	42	10.2
Flat-Rate Public Water and Public Sewers		
(8 areas in West)	420	113.0
Apartment Areas		
(5 areas both East and West)	18	6.9
Total of 41 Areas	160	42.0

Source: Linaweaver _et al_. (undated)

Table A-5

RESIDENTIAL OUTSIDE CONSERVATION POTENTIAL

Location/Activity	Improved Design	Water Saved: Percent of Conventional Use	Water Saved: gpcd
Meters	Metered	50 of unmetered sprinkling or 30 of unmetered residential use	25-40
Pressure Reducing Valve	50 psi (Max)	10-20 of outside use	3-6
Efficient Sprinkling	Approx. Evapotranspiration	10-15 of remaining outside use	2-3[a]
Drought Resistant Vegetation	Major Landscaping Consideration	20-25 of remaining outside use	3-4[a]
Education	Avoid Waste	5-10 of remaining outside use	½-1[a]
TOTAL			9-14[b]

a. Low estimate to lessen double counting.

b. Assumes 10% residences now unmetered and 30% need pressure reducing valve.

Table A-6

RESIDENTIAL OUTSIDE CONSERVATION POTENTIAL (ECONOMICS)

	Additional Cost/Residence (in $)		Benefit/Cost Ratio[a]	
Location/Activity	New or Extensive Remodeling	Retrofit Material (Labor)	New or Remodel	Retrofit
Meters	100	100 (+300)	2.3-3.7	0.6-0.9
Pressure Reducing Valve	30	30 (+ 20)	3.3-6.6[b]	2.0-3.9[b]
Efficient Sprinkling	25-300	100-300 (+100)	0.1-1.1[c]	0.1-0.2[a]
Drought Resistant Vegetation	35-200	500-1000(+500)	0.1-1.1	0.0
Education	$2/Residence-Year		0.2-0.4[c]	

a. Assumes 7% interest, 20 year life, and water at 60¢/100 gallons

b. Includes in-house water savings

c. Low estimate of water saved to lessen double counting conserving actions (e.g. drought resistant vegetation) appear to be marginal at best. Unfortunately, the numbers used to derive this table do not yet have a strong research basis, thus these results must be viewed with caution. The cost estimates particularly need to be improved.

3. Conservation Potential in Other Municipal Uses

Even less information is available as a basis for estimating the conservation potential for the commercial, public, industrial, and losses (due to leakage) portions of municipal water supply. To a great extent these estimates must be based on extrapolation of the findings for residential potential.

As a first characterization of the conservation potential for these other uses, it is estimated that 20 to 40 percent savings could be achieved on the average by nationwide application of reasonable conservation measures. The following are the main reasons behind this estimate:

- Public and commercial uses involve many of the same fixtures and activities that residential uses do -- e.g., toilet flushing, showers, dishwashing, landscape watering, etc.
- In addition, there are other opportunities for savings in commercial water use -- e.g., a large portion of the water for car and bus washing can be recirculated.
- In industrial use there is also the opportunity for toilet flushing and shower water conservation and there are three other factors pointing toward conservation as well:
    - Industries must meet increasingly strong standards both in terms of treating the wastewater they discharge to the environment and pretreating the wastewater they discharge to public sewers.
    - Industries which discharge to public sewers now pay sewer user charges based on the volume and strength of their wastes.
    - Water suppliers are increasingly moving toward rate structures which penalize avoidable use and other users insist that this pricing philosophy be applied to industries as well.

- Water system losses are also the subject of increasing attention including significant concern with leakage in the older distribution systems found in some eastern cities. The American Water Works Association recently (February, 1979) chose leak detection and repair as the theme for an issue of its monthly journal. Although quantitative information is sparse, one indication of potential is the new leak detection program of the East Bay Municipal Utility District encompassing Oakland, California, and adjacent areas. Laverty (1979) estimates that leakage detection and repair equals 4 percent of total metered usage and that 2.5 of these 4 percent have been due to new emphasis on leakage control. This compares well with the 2 to 4 percent which is implied by the conservation potential estimated above, especially since other communities are believed to have more leakage to start with.

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Appendix B

DETAILED ANALYSES OF THE "REALISTIC" WATER CONSERVATION SCENARIO

1. Typical Family of Four

A foremost question to be asked in determining what changes will be necessary to convince the public to support water conservation is: "Would the typical family of four have more discretionary income as a result of a conservation program?" To address this question within the context of the realistic scenario (high cost and low savings), the following additional assumptions beyond those in Section IX. B.4 are made:

- Retrofit is done for toilets (e.g., using tank inserts), showers and faucets, and a pressure reducing valve is installed where appropriate.
- Water price per gallon is not affected by conservation; the family is assumed to be deciding on its own whether to conserve and it presumes that the number of families conserving will not significantly lessen total community water demand or cause increases in water rates (this assumption will be changed in the next section).
- Water price is 60¢/1000 gallons.
- Gas price is 25¢/therm.
- There is no change in the family's wastewater bill.

The following impacts result:

- Total water saved -- 76 gpd.
- Hot water saved -- 13.2 gpd.
- Water heating energy saved -- 9,900 BTU/day.
- Conservation cost -- $100 (see Table B-1).

The associated changes in annual water-related costs are as follows:

- Amortize $100 (7%, 20 years) -- Cost = $ 9.44
- Change in water bill -- Savings = 16.64

. Change in gas bill -- Savings = 9.03

. Net Savings -- 16.23

. B/C ratio -- 2.7

From a benefit/cost ratio point of view, these actions appear quite attractive. It seems questionable, however, how much the net annual savings of $16.23 would motivate the family to do in the way of conservation. Note that the savings in energy costs are due to the hot water saved.

Table B-1

TYPICAL FAMILY OF FOUR --
CONSERVATION RETROFITTING COSTS FOR
THE REALISTIC SCENARIO

Action	Material	Labor	Total
Toilet Inserts (2)	$10	$10	$ 20
Showerheads (2)	10	8	18
Lavatory Faucets (2)	4	4	8
Kitchen Faucet	2	2	4
Pressure Reducer	30	20	50
Totals	$56	$44	$100

2. The Community

a. With No Population Growth and Large Fixed Costs for Water Supply

An important question to ask in determining effective incentives for conservation is: "Do water rate increases wipe out the family's conservation savings"? This phenomenon has been observed recently in communities which have successfully reduced water demand very rapidly in response to drought. Reduced demand has led to higher rates because of the utilities' high proportion of fixed costs.

To investigate this phenomenon, consider the net savings to the typical family of four in a community experiencing no growth and under the following assumptions:

- The same conservation program is implemented.
- It is implemented throughout the community.
- 90% of the water utility costs are fixed (thus if water demand decreases, the price of water must be raised).
- Gas price per therm is not affected by water conservation.
- Residential wastewater charges are by flat rate and don't change.

The impact of these conditions is a water rate increase from 60¢ to 74¢/1000 gallons. Consequently, the family's net savings fall from $16.23 to $1.25 and the corresponding benefit/cost ratio falls from 2.7 to 1.1. Note that even under the very conservative assumptions used, the conservation program is still economically advantageous.

b. <u>With Moderate Growth and Need for New Capacity</u>

In contrast, the case of a community with moderate growth leads to a pertinent question: "What is the cost advantage of being able to postpone capital expenditures"? The following assumptions imply the impact on water supply depicted in Figure B-1 and on wastewater in Figure B-2:

- Community size -- 50,000.
- Growth rate -- 2%/year.
- Water supply average annual capacity -- 10.5 mgd.
- Present demand (equals national average in Table IX-1, 190 gpcd) -- 9.5 mgd.
- 20% conservation is implemented over a 15-year period so demand is never less than 9.5 mgd.
- Cost per residence for conservation retrofit -- $100
- Cost per new residence to include conservation -- $50

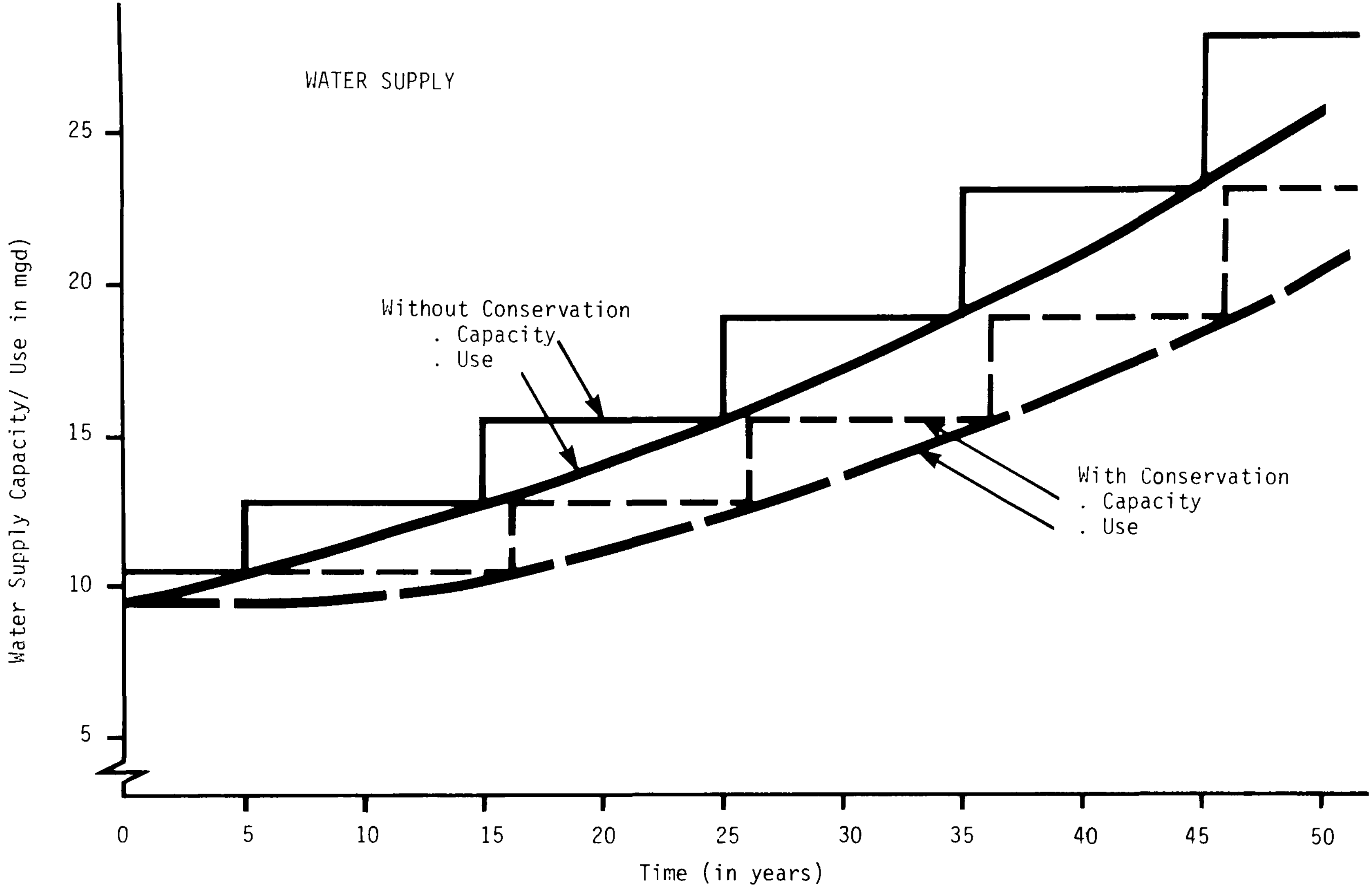

Figure B.1 IMPACT ON WATER SUPPLY OF 20 PERCENT CONSERVATION IN A COMMUNITY WITH MODERATE GROWTH

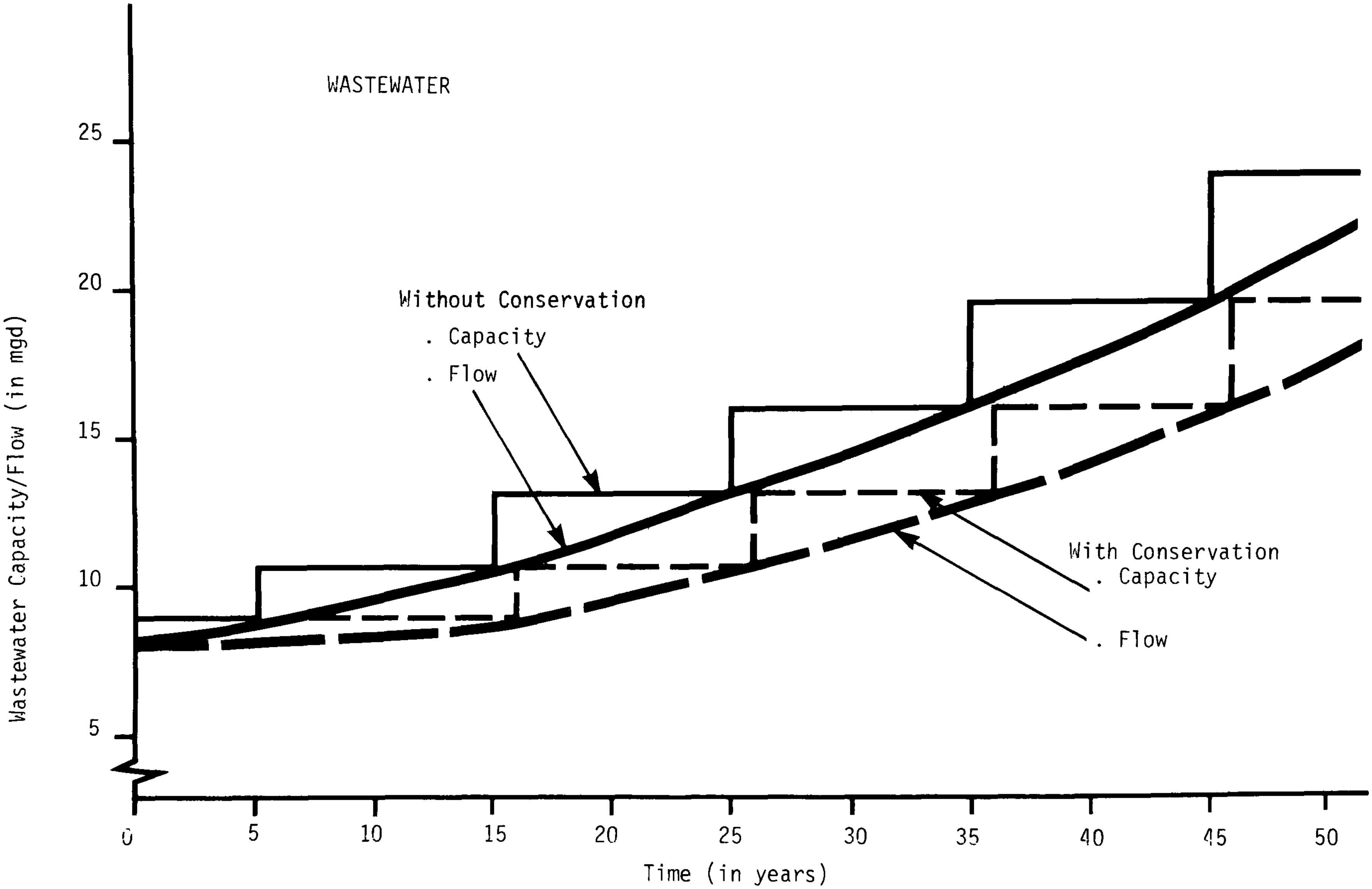

Figure B.2 IMPACT ON WASTEWATER OF 20 PERCENT CONSERVATION IN A COMMUNITY WITH MODERATE GROWTH

- Cost of conservation for other municipal uses is the same cents per gallon saved as for the residential use.

- Wastewater treatment capacity -- 9.0 mgd.

- Wastewater flow (equals national average, 160 gpcd, Metcalf and Eddy, 1978) -- 8.0 mgd.

- Water supply capital cost for new expansion -- $1,000,000/mgd.

- Water supply operation, maintenance, and replacement costs (Temple, Barker, and Sloane, 1977) -- 40 cents/1000 gallons.

- Hot water energy savings (5 gpcd) -- 6.82 X 10^3 BTU/capita-day.

- Energy cost -- $20/barrel of oil equivalent.

- Wastewater capital cost for treatment capacity expansion (Dames and Moore, 1978a) -- $2,000,000/mgd.

- Wastewater treatment capital savings from 20% conservation are assumed to be only 5% due to higher wastewater strengths (after Tiemens and Graham, 1978).

- Extra savings occur during the first wastewater treatment expansion because hydraulic capacity does not need to be modified.

- Capital savings on interceptor and trunk sewer sizes -- assumed to equal treatment savings (after Tiemens and Graham, 1978).

- Wastewater treatment and sewer system operating, maintenance and replacement costs ($20/capita-year, Dames and Moore, 1978b) -- 34¢/1000 gallons.

- Wastewater treatment and sewer system operating, maintenance and replacement savings from 20% conservation are assumed to be only 5% due to higher wastewater strength.

Detailed computations of monetary savings due to conservation were made under the above assumptions and results are summarized in Table B-2. By virtue of the relatively small cost to implement conservation and the

Table B-2

ECONOMIC IMPACTS FROM REALISTIC CONSERVATION
SCENARIO IN A GROWING COMMUNITY

(Present Population, 50,000; Growth, 2 percent/year)

	Present Value (million dollars)
Costs to Implement Conservation	
. Retrofit present residences, commercial and public buildings, industries, and repair leaks	1.51
. Incorporate water conservation in all new construction	0.35
Present Value of Total Construction Cost	$1.86 million
Dollar Savings from Conservation	
. Water supply cpaital expenditures delayed	2.17
. Water supply operation and maintenance savings	3.64
. Water heating energy savings	5.40
. Wastewater capital expenditures savings	1.61
. Wastewater operation and maintenance savings	0.59
Present Value of Total Conservation Savings	$13.41 million
Benefit to Cost Ratio for Conservation	7.2

combined savings especially due to less need for future water supply and for energy to heat water, the conservation program is extremely attractive. With the conservative assumptions used, the benefit to cost ratio is 7.2. In actually implementing such a program, it is likely that the ratio will be even more attractive.

c. Regarding Community Balance of Payments

An associated question pertinent at the community level is: "Does conservation mean less money (e.g., wastewater construction grants) coming into the community?" The following assumptions underlying the community money flow model in Figure B-3 lead to the changes in the community balance of payments displayed in Table B-3:

- All water supply, water heating and wastewater expenditures must be allocated to in or out of community.
- All operation labor expenditures stay in the community.
- Half of the construction labor expenditures stay in and half flow out of the community.
- All interest expenditures flow out.
- All energy expenditures flow out.
- All construction materials and equipment expenditures flow out.
- All other operating expenditures flow out.

The bottom line of this modular representation is that realistic water conservation will provide a significant (13%) reduction in the community's payments deficit for water-related services under the fairly conservative assumptions used.

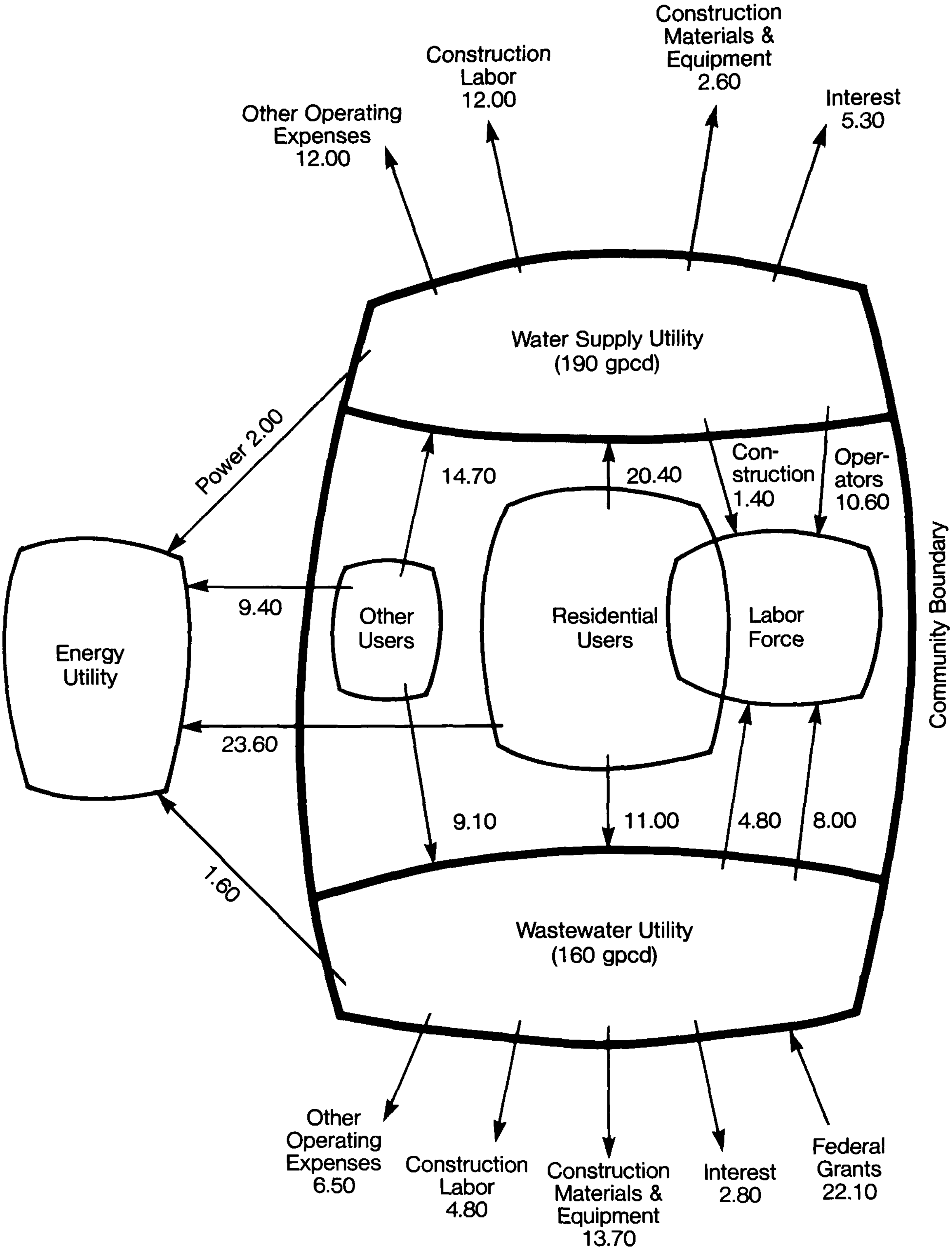

Figure B.3 ESTIMATES OF WATER-RELATED MONEY FLOW IN A TYPICAL COMMUNITY WITHOUT CONSERVATION ($/CAPITA-YEAR)

Table B-3

COMMUNITY BALANCE OF PAYMENTS
CHANGES DUE TO CONSERVATION

(In dollars/capita-year)

Money Inflow	Without Conservation	With Conservation
Water Supply	0	0
Wastewater	22.10	21.20
Total In:	22.10	21.20
Money Outflow		
Water Supply	23.10	20.50
Wastewater	29.40	28.10
Residential Energy	23.60	18.90
Other User Energy	9.40	7.50
Conservation Equipment	0	1.60
Total Out:	85.50	76.60
Net Outflow	63.40	55.40

Net Change: $8/capita year less flow out equals 13% reduction in payments deficit.

References: Appendix B

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